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Rust in Water Pipes Removed by New Method. Rust-choked iron water pipes in a 35-story New York office building have been cleared by a new acid solvent, and the vast expense of repiping the whole structure avoided. The process, worked out by F. N. Speller, E. L. Chappell, and R. P. Russell of the Massachusetts Institute of Technology, is expected by engineers to become a very important factor in building management.

It has long been known that a solution of hydrochloric acid in hot water will dissolve rust, but the drawback has been that it will also dissolve iron and steel so that it has never been considered practicable for use on a large scale. The three Massachusetts engineers, however, added an organic "inhibitor" which has the effect of preventing the acid from corroding the metal while still permitting it to attack the rust.

In order to carry out their operations with the least possible inconvenience to the tenants, they divided the plumbing of the building into sections, attacking these one by one on Saturday afternoons so that the solution could get in its work and be flushed out of the pipes before the resumption of business on Monday morning.—*Science Service*

Scurvy-Preventing Vitamin Shown to Be Present in Milk. Vitamin C, the substance that wards off scurvy, is present in milk, as well as in the fresh vegetables usually relied upon to supply it, and included for this reason in all standard diets for children. Prof. L. F. Meyer, of the University of Berlin, states this as his conclusion after an extended series of experiments.

Prof. Meyer was led to undertake his researches by the high occurrence of scurvy among the children in German cities during the period of hard times just after the war. Not only the fully recognizable disease but also such partial forms as arrested growth and sub-normal development among children were distressingly manifest. While the supply of fresh vegetables was not up to standard, the German scientist suspected that the milk shortage also had something to do with it.

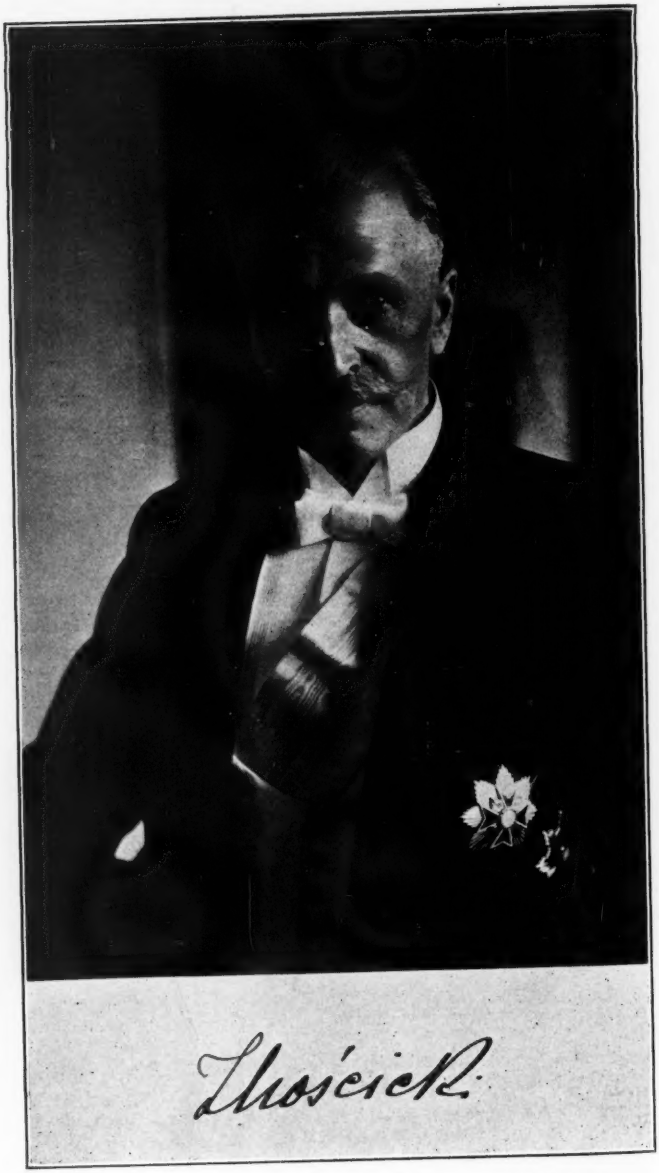
Tests on guinea pigs kept on a deficient diet have shown that milk can prevent scurvy, he says. Human milk stands at the top of the list as a source of vitamin C, thus explaining the fact that breast-fed babies rarely or never contract this disease. On the other hand, Dr. Meyer found that goats' milk, much used in Europe for infant feeding, is quite deficient in this necessary substance. In this respect cows' milk is much superior to that of goats.—*Science Service*

Smoke and Pneumonia Relationship Needs Probing. Smoke in its relationship to pneumonia, the most prevalent and fatal of all acute infectious diseases, was brought under the spotlight in a recent report by Dr. W. C. White and the U. S. Public Health Service to the American Society of Mechanical Engineers.

The fact that Pittsburgh, one of the smokiest cities, has the highest constant death rate of any community in the world, and that the pneumonia death rate of the city by wards is higher where the smoke content of the air is densest, indicates that smoke has a tremendous influence on this disease, Dr. White said.

Definite proof of this correlation is still lacking, he pointed out. Further research in the field is necessary, he said, with doctors and engineers coöperating, to determine the effect of smoke upon health. Dusts associated with carbon in smoke are probably much more important than the carbon, he stated. They should be carefully studied to enable us "to speak with authority not only about the pollution of the air with carbon, but also about all the dusts that may now or in the future pollute the air we breathe."

It is probable, said Dr. White, that smoke has an evil influence on pneumonia, but that it bears no relation to the tuberculosis death rate or to the death rate from cancer. Pittsburgh, he pointed out, has a low tuberculosis death rate and a comparatively low death rate from cancer.—*Science Service*



Ignace Mościcki, President of the Republic of Poland

EDITOR'S OUTLOOK

ELSEWHERE in this issue appears an outline of the rapid industrial development which has been taking place in Poland since the war. Yet no picture of Polish conditions which omits a portrait of President Ignace Mościcki can be considered at all complete. Throughout, he has been a directing and stimulating influence in Polish affairs.

Ignace Moscicki, Chemist-President

The childhood of Ignace Mościcki was passed on the family estates in the country near Zamość and it was there that he received his early education. Later he attended the gymnasium at Warsaw and eventually majored in chemistry at the Polytechnic School at Riga.

In his student days he had already begun to give evidence of the qualities of leadership and scholarship which later distinguished him, for he took a prominent part in academic and social activities. The ardent patriotism characteristic of the Pole was intensified in him and at the close of his university career he returned to Warsaw and devoted himself to the movement for national independence. Whatever other result his activities may have had, they at least attracted the attention of the Russian government and he soon found himself obliged to leave Warsaw.

He settled in London and there devoted himself to his profession for about five years, at the end of which time he removed to Switzerland. At Fribourg he was offered the chair of physics in the University and a few years later was entrusted with the direction of all scientific work in its newly erected laboratories.

Quite a number of important inventions resulted from the work which he did there during the years between 1901 and 1912. Foremost among these was a method for the production of nitric acid by means of an electrical discharge. In connection with that process it was necessary to make a study of high-tension condensers and to evolve a new design to meet the special conditions imposed. The new condenser proved immensely valuable both from the theoretical and the technical standpoint and a factory was erected at Fribourg for the purpose of constructing it in quantity. It was in this factory that the battery for the Eiffel tower—the largest of its time—was constructed.

Not yet satisfied with his earlier work on the synthesis of nitric acid, Professor Mościcki again attacked the problem and finally perfected a method ten times as efficient as the best which had been devised up to that time. With the new process as a basis a factory was built at Chippe for the manufacture of nitric acid. During the war, when Switzerland was cut off from Chilean nitrates, this plant was able to supply all needs.

The last of Professor Mościcki's outstanding enterprises in Switzerland was the development of a calcium cyanide process and the construction of an experimental plant at Neuhausen. Throughout this period one dominant quality is evident—an astonishing capacity for the application of theoretical principles to the solution of practical problems.

But although his work had been accompanied by outstanding successes the ardent spirit of the Polish scholar was not completely satisfied. He deeply desired to return to Poland that he might place his talent and experience at the disposal of his native country.

In 1912 he was offered the chair of physics and electrochemistry at the University of Leopol. Inspired by the fact that he was once more on Polish soil he renewed his practical activities, but in no way at the expense of his pedagogical and scientific work. In 1916 he was instrumental in founding at Leopol an experimental chemical institute which has recently been removed to Warsaw where it is dedicated to the investigation of both theoretical and practical problems.

But the practical and theoretical activity of Professor Mościcki did not stop with the institute. In 1917 the construction of a nitrate factory was begun under his professional direction at Jaworzno near Cracow. The World War prevented its completion and it was only finished in 1921 under the government of an independent Poland.

Professor Mościcki's ability as an inventor, organizer, and genius was shown most eminently in the reorganization of the synthetic nitric-acid factory at Chorzow which had been awarded to Poland as a result of the war. When the Polish government took possession the Germans withdrew the personnel and left no plans or directions which might have aided the Polish people in its operation. Professor Mościcki, however, was able to rise to the occasion and not only to put the plant into operation at once, but to introduce improvements which had been unknown to the Germans themselves. At the very start this factory was able to produce thirty cars of nitrate per day.

Although the nitric acid field was Professor Mościcki's specialty, his inventive faculties were by no means confined to it. He devised means for breaking crude petroleum emulsions and introduced new methods of distillation, thereby making possible the utilization of enormous quantities of petroleum which up to that time had laid dormant.

The scientific, industrial, and executive activities of Professor Mościcki earned him an eminent place in the scientific world. His scientific work, however, had always gone hand in hand with social and civic activity. At Zurich his home was the center of social life for the Polish emigrants who had been forced to leave their country. His laboratories were a point of assembly for the young Polish students.

After his return to Poland, and especially after Poland had gained her

independence, his professional and patriotic activities merged. In politics he was always a partisan of Marshal Pilsudski. It was not surprising, therefore, that, after the events of May, 1926, and the crisis which followed, he should have been elected President of the Polish Republic.

At present in spite of the great amount of time and thought required by his political duties he has not broken contact with industrial and professional developments in Poland. He takes time to keep personally in touch with both of these fields and as a result both are progressing in an astonishing fashion. The Congress of Pure and Applied Chemistry which held its eighth annual meeting at Warsaw in September of this year was brought there at his special invitation.

Sectioning According to Capacity

AFTER years of evangelism on the part of leaders in educational thought, general opinion is beginning to acknowledge the desirability of—indeed, the necessity for—more individualized instruction. Unable to relinquish our sacred democratic philosophy of education we have at last succeeded in harmonizing the gospel with the actuality. We have abandoned the untenable assumption that all jugs have equal capacities and have re-defined educational democracy to mean that a quart jug should be filled with a quart and a gallon jug with a gallon, rather than that a half-gallon should be allotted to each alike.

Ironically enough, the possibility of putting individualized instruction into effect appears more remote at the present moment than ever. That is, it appears remote if we interpret individualized instruction to mean an appreciable amount of personal attention to each individual student. The expansion of faculties does not begin to keep pace with the expansion of student bodies. As ever, we are herded by stern reality along a road not of our own choosing even while our eyes linger despairingly upon the path indicated by ideality.

But is the picture indeed one of utter gloom? Must we accept these limitations and attempt to drown their memory in a fatalistic resignation to things as they are? Perhaps not. Since we must work with groups rather than with individuals, there is still the possibility of group differentiation. And this solution is not, after all, the mere makeshift which it might appear at first thought.

Let us reëxamine our ideas concerning individual instruction. Theoretically it derives its primary advantage in the stimulating personal contact between an inspirational teacher and an eager, intelligent pupil. History is replete with references to such ideal relationships.

But can we assume that every teacher or every student is capable of entering into such a relationship? Teachers will readily admit that not every student can qualify, and if considerations of professional loyalty prevent them from making a similar admission about other teachers, we will add as much on our own responsibility. We may, therefore, lay this picture aside as a pleasant dream which now and then achieves or approximates reality but which cannot be conjured up at will and which must necessarily, on that account, be left out of our more serious calculations.

From an administrative standpoint, wherein does the problem presented by the exceptional student arise? Simply in the fact that he is better or worse than the group. He destroys its uniformity. But is this differentiation of a nature to make him utterly unique for purposes of instruction? Generally speaking, we believe that it is not. It is axiomatic that human beings are infinitely diverse, but it remains equally true that relatively few of their infinite diversities affect their reactions to instruction. The most significant of these are ability and power of application. For instructional purposes, therefore, one superior student is not so different from another superior student, nor one inferior student from another. Either is conspicuous only when he is a member of a "normal" group.

Statistical considerations make it plain that we have only to work with large enough numbers to enable us to select our groups by stratification rather than indiscriminately. The original difficulty becomes its own solution.

Naturally it is desirable that such separation be made as accurately as possible at the very outset rather than left to the slower processes of trial and error. Fortunately, we already have at our disposal certain prognostic tests which are not without merit. And if one hesitates to rely exclusively upon a somewhat less than infallible estimate of form he may call past performance into account by examining previous school records.

It may be that the solution seems too easy. If we have appeared to endorse a panacea, we herewith deny any such intention. We hope only to point out that, while ideal conditions are by definition, if for no other reason, unattainable, progress based upon ideal considerations is not automatically estopped.

X-RAYS AND CHEMISTRY

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As the frontiers of knowledge are pressed forward the boundaries between the provinces of the several sciences become less and less distinct. The atom, for instance, began in modern science as a convenient mental conception for the chemist; it has become a reality and a fascinating problem to the physicist. Thus the methods and data of a particular science become increasingly useful to the other sciences, and it is no cause for surprise that the chemist should have found in x-rays, a comparatively recent discovery of the physicist, an instrument with which to investigate his own peculiar problems. It would be erroneous to suppose, however, that the chemically important information that x-rays have yielded has been obtained only by the chemist. Indeed much of this new knowledge has been procured by the physicist, who, working at his own problems, has made discoveries valuable to chemistry. The chemist is not yet so adept nor so well acquainted with this new tool as we may well expect him to be in the future. But, whether guided by the hands of the physicist or the chemist, x-rays have been a powerful influence in the chemistry of the recent past; and we may be sure they will continue, as they are focused more and more by the chemist on the problems peculiar to him to aid and influence the chemistry of the future. To present the history of x-rays in chemistry to the present time and to indicate, in a general way, how they may be of help in the future is the purpose of this paper.

Electrons and X-Rays

Some prefatory remarks about x-rays themselves will be necessary and these must begin by noting a few facts about electrons. Electrons, as now conceived, are small corpuscles endowed with a minute charge of negative electricity. All electrons are identical; their mass is almost negligible, being only 1/1800 of the mass of the hydrogen atom; and their electrical charge has been found by Prof. R. A. Millikan to be 4.77×10^{-10} electrostatic units. Transfers of electricity in smaller amount than this have never been observed and so far as we know today electrons are indivisible; they are, indeed, the primordial units of negative electricity. Experiment has also shown that they may be obtained from atoms of any chemical element whatever, and that the atom is in a new state after the withdrawal of the electron or electrons. In this new state the atom has a positive electrical charge equal in magnitude to the sum of the charges of the withdrawn electrons. The atom is said to have been ionized and the positively charged atom is called a positive ion. When the electron, or electrons, become again affiliated with the positive ion, it resumes the state it occupied before the removal. Thus, the electron is not only the

primordial unit of negative electricity, it is, as well, a structural unit in the architecture of the atom. The primordial unit of positive electricity, or proton, as it is sometimes called, is less well known for it is rather more difficult to obtain for experimental study; and no discussion of it is necessary here.

X-rays are produced when streams of fast-moving electrons are suddenly stopped by impinging upon matter. These electron streams are known as cathode rays, for they were first observed, many years ago, emanating from the cathodes of partially evacuated electric discharge tubes. For the generation of x-rays, then, three things are necessary: a source of electrons, a means of imparting a high velocity to them, and a target to stop their flight. Electrons may be obtained in several different ways. One of the most important is based upon the fact that they are spontaneously emitted by hot bodies. Since electrons bear electrical charges they may be accelerated to high velocities by passage along a high potential gradient, and this is the invariable means of speeding up the electrons, however they may have been originally obtained. A block of any solid matter may be used as a target; practically, the elements tungsten, molybdenum, iron, and copper are the most frequently employed. The tube most widely used in this country, the Coolidge tube, is designed on the above-mentioned principles. This tube is provided with a wire filament which may be heated to supply the electrons; the filament is the cathode, the target the anode, and a high potential (30 k.v. is a representative potential drop) is imposed across these electrodes. The tube is evacuated to such a degree that no discharge will take place through it when the filament is cold and hence not emitting electrons. When the filament is heated and the high potential applied, electrons leave the filament and are accelerated across the intervening space to the target against which they are hurled; their kinetic energy is transformed by the impact into radiant energy, which appears as x-rays. It must not be supposed that this is by any means a complete discussion of the generation of x-rays, but neither circumstances nor space warrant a more detailed treatment here. The method outlined does, however, illustrate the general principles in a simple manner and with sufficient detail for the present purpose.

X-Rays as Waves

X-rays are one of several families of rays, all having the same fundamental nature. Ordinary light rays, ultra-violet rays, heat rays, radio rays, and γ-rays from radio-active disintegration are others of these families. Light, known to man from his first appearance upon the earth, and the only one of the families recognized until quite modern times, has been studied by scientists for many years. Yet the nature of light and of all these rays remains, even today, one of the great fascinating and per-

plexing problems of physics. The experimental facts are that the phenomena exhibited by these rays fall into two quite distinct classes. The phenomena of the one kind, of which the interference of light is a typical example, may be explained by the conception of light as a wave motion. This is the older theory, and in the nineteenth century it was submitted to many rigorous tests, all of which it withstood with striking success. The brilliant theoretical synthesis, by Clerk Maxwell, of experimental observations made by Faraday on electricity and magnetism provided a conception of these waves as oscillating and mutually perpendicular magnetic and electric fields, brought into existence by the periodic vibrations of an electric charge. The theory scored an initial triumph by providing a calculated speed of light, based upon electrical and magnetic measurements alone, which agreed exactly with the measured speed. It also suggested that rays similar to light, but of different wave-length, might be produced, a prediction which Hertz experimentally verified by producing, with an oscillating electric spark, what we are now familiar with as very short radio waves. The identification of x-rays as one of these families by the demonstration of their ability to exhibit phenomena of this kind did not come until nearly twenty years after their discovery, when it was predicted by Laue, and verified by experiment, that x-rays could be diffracted by crystals, a phenomenon of fundamental importance, and of which we shall have a good deal more to say later. Today rays of this nature, varying in wave-length from 0.0004 Ångstrom unit (Å. U.—one Å. U. is 1×10^{-8} cm.) to many thousands of meters, are recognized. In this range x-rays lie roughly between 0.06 Å. U. and 500 Å. U., while all visible rays, *i. e.*, ordinary light, lie between 3900 Å. U., the lowest limit of the violet, and 7700 Å. U., the upper limit of the red.

X-Rays and the Quantum Theory

Phenomena of the other kind seem to demand that radiation energy be propagated in small, discrete bundles, or quanta. This idea was first advanced by Max Planck, who, in 1900, achieved an explanation of certain heat radiation phenomena by its use. The size of the quantum depends upon the frequency ($\nu\lambda = c$, where ν is the frequency, λ the wave-length, and c the velocity of light, 3×10^{10} cm./sec.) of the radiation in question and equals $h\nu$, where h is Planck's action constant. Thus, though the wave and quantum phenomena seem enormously discrepant, they are indissolubly bound together by this relationship. Many quantum phenomena are now known, and in the x-ray field one of the most important and interesting is the photoelectric effect. If matter is exposed to x-radiation, electrons are ejected from it; this is the photoelectric effect for x-rays. The velocities of the ejected electrons can be measured and their energy calculated. The remarkable fact about the process then

appears; these electrons seem always to have picked up an amount of energy equal to the quantum of the incident x-rays, namely $h\nu$. Furthermore, if a certain amount of energy is required to lift the electron out of the atom before it may be given velocity as a free electron no such electron will be ejected if the $h\nu$ value of the incident radiation is less than this prerequisite amount. When the $h\nu$ value exceeds this amount the excess is imparted to the electron as kinetic energy. Thus:

$h\nu = W + {}^1/_2\, mv^2$, where W is the energy necessary for removal of the electron and ${}^1/_2\, mv^2$ is its kinetic energy as a free electron. A simple statement of the situation is: if x-rays are produced by the impact of electrons of known velocity upon a target, and these rays then eject electrons from a secondary target, the fastest of the ejected electrons has the velocity of the primary electrons. This phenomenon was known before that of diffraction by crystals and indeed seemed a powerful argument against the similarity of x-rays and light.

The apparent contradiction between these two sets of phenomena has not yet been completely explained, though it is receiving the constant attention of physicists and progress is being made. Sir William Bragg has very neatly expressed the difficulty in a simile. "It is as if one dropped a plank into the sea from a height of 100 feet and found that the spreading ripple was able, after traveling a thousand miles and becoming infinitesimal in comparison with its original amount, to act upon a wooden ship in such a way that a plank of that ship flew out of its place to a height of 100 feet."

Crystals and X-Ray Diffraction

Of what are, perhaps, the two most important fundamental phenomena in the applications of x-rays to chemistry, one, the photoelectric effect, has just been discussed. To understand the other, the diffraction of x-rays by crystals, some knowledge of the architecture of crystals is necessary. A crystal is built up by the repetition in all directions in space of a unit building block or unit cell. This unit cell is a parallelopipedon and is the smallest aggregation of atoms or molecules in the crystal which can display all the properties of the large crystal. It may contain few or many of the chemical elements or molecules of which the crystal is composed. Sir William Bragg, speaking of the differentiation between atoms, molecules, and crystal units, said, "The separate atoms of silicon and oxygen are not silicon dioxide, of course; in the same way the molecule of silicon dioxide is not quartz; the crystal unit consisting of three molecules arranged in a particular way *is* quartz."

The regular and definite arrangement of the atoms or molecules within the unit cell is an essential feature of its construction. This regularity of arrangement imparts symmetry, of higher or less degree, to the unit cell and, hence, to the large crystal. This symmetry manifests itself in

some of the properties of the crystal and most obviously in the crystal's external form. Indeed, before x-rays were applied to crystal study crystallographers had been able, by a consideration of the possible ways of combining the various elements of symmetry[1] and arranging these combinations in space, to tabulate and classify all possible arrangements of points in space which could give crystals their observed symmetry characteristics. As will, perhaps, be more apparent when the discussion of diffraction is complete, x-ray crystal analysis provides a means of determining more or less completely the disposition of atoms within the unit

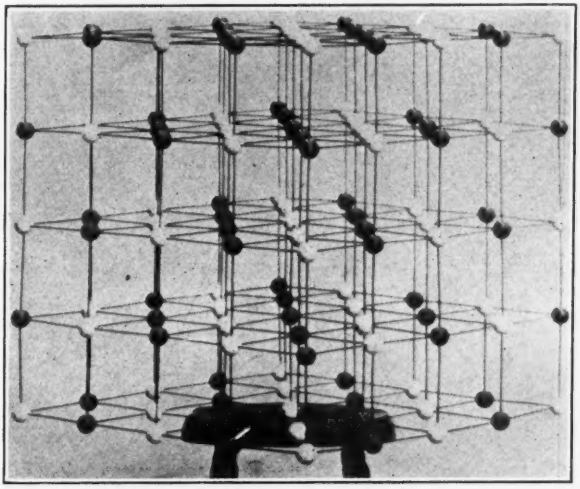

FIG. 1.—MODEL OF A SODIUM CHLORIDE CRYSTAL

cell of an actual crystal and thus identifying the crystal with one of the known possible arrangements.

Fig. 1 is a photograph of a model of an actual crystal, sodium chloride, thus constructed by the repetition of unit cells. The white balls represent atoms of one kind; the black, atoms of the other. This particular model shows eight cubical unit cells. It is important to notice that an

[1] An element of symmetry specifies one of a number of operations, which, when performed upon a point in the crystal, brings it into coincidence with an exactly similar or equivalent point, which may be the original point, in the crystal. Thus, an axis perpendicular to the center of a cube face is a four-fold rotation axis of symmetry, since a rotation of 90° about it will bring any point, *e. g.*, a cube corner, into coincidence with an equivalent point. Some other symmetry elements are: planes of reflection, which specify a reflection perpendicular to the plane; and axes of rotation and reflection, which specify rotation about the axis and a subsequent reflection in a plane perpendicular to it.

atom may belong to more than one unit cell. Thus it is obvious that the white ball in the center of the model belongs to each of the eight unit cells represented; as the crystal is magnified by the repetition of these unit cells in all directions it is seen that the corner atoms of each cell belong as well as to the other seven adjacent cells. Again it should be observed

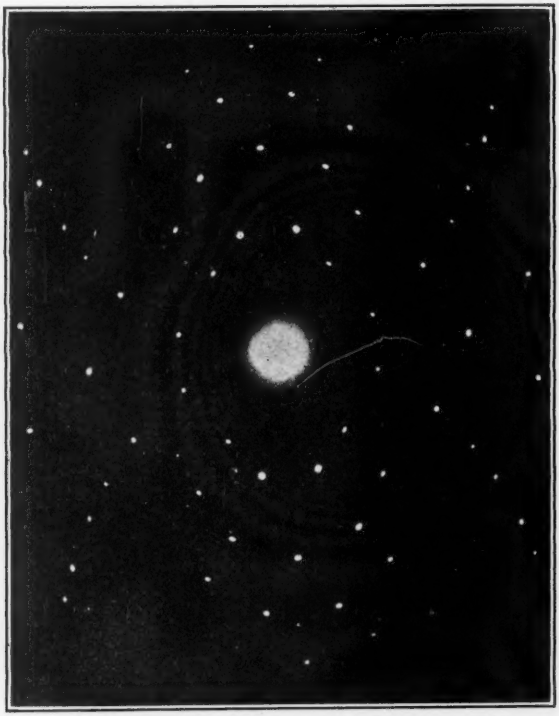

FIG. 2.—X-RAY PHOTOGRAPH OR LAUE DIAGRAM OF A SINGLE IRON-CRYSTAL

When x-rays are defined by pinholes and pass through a grain of iron, they are diffracted by the iron-crystal grating and produce the diagram shown. Each of the spots corresponds to the reflection of x-rays of a definite wave-length by one set of parallel planes in the crystal.

that the atoms are arranged upon a regular framework or lattice. There are known to be 14 of these lattices of which the one in the figure is known as the simple cubic.[2] These lattices may be thought of as the intersections of three different sets of parallel equidistant planes. It must be emphasized that this model is of one of the simplest crystals and that

[2] All crystals may be considered as constructed by placing atoms, or groups of atoms characterized by a certain symmetry, on or about the points of these space lattices.

unit cells are not by any means always cubes. To attempt a detailed discussion of the various crystal classes here, however, might easily prove more confusing than helpful.

Now the average magnitude of the distances between atoms in crystals can be calculated from the density, atomic or molecular weight, and Avogadro's number, and is found to be of the order of magnitude of x-ray wave-lengths (*i. e.*, 1×10^{-8} cm.). From this fact and the regularity of arrangement of the atoms within the crystal, Laue argued that crystals should be three dimensional diffraction gratings for x-rays and, in particular, that a beam of x-rays, including a range of wave-lengths, should, when passed through a crystal, be bent in various directions, *i. e.*, diffracted, the directions depending upon the crystal structure and the wave-lengths in the beam. His prediction was soon verified. Fig. 2 shows the really beautiful pattern obtained upon a photographic plate when such a beam is passed through an iron crystal. The heavy central spot is the original, undiffracted beam.

Although Laue's original mathematical treatment of the phenomenon was complicated and difficult, the Braggs were able to effect an important simplification. A glance at Fig. 1 will show that sets of parallel and equidistant planes containing varying numbers of atoms and making a variety of angles with the edges may be passed through a crystal. The Braggs were able to show that the diffraction of x-rays by crystals might be considered as a reflection of the beam by these sets of planes. This reflection is similar to ordinary mirror reflection in that the angle of incidence equals the angle of reflection and the reflected beam lies in the same perpendicular plane to the reflection planes as does the incident ray. It is, however, distinguished by the peculiarity that reflection will occur only when a particular relationship exists between the angle of incidence, θ, the perpendicular distance, d, between two successive planes of the set, and the wave length, λ. This relationship, known as the Bragg Law, is given by the equation $n\lambda = 2d \sin \theta$ (where n is a positive integer).

Thus, it is immediately obvious that given a definite set of crystal planes, arranged at a fixed angle of incidence to a beam containing, say, a number of wave-lengths, only one of these wave-lengths will be reflected. Or, if the beam is monochromatic, that is, if it contains only one wave-length, reflection will occur only at certain definite angles of incidence. An experimental arrangement which will provide a means of measuring the angles of incidence at which reflections take place thus enables two kinds of investigation to be made. In the first, a crystal of known spacing is used to determine the wave-lengths in a beam of unknown composition; and in the second, a beam of known wave-length serves to measure an unknown spacing. The existence of a reflection may be discovered by placing a small chamber containing a suitable gas, *e. g.*, methyl iodide,

in the path of the reflected beam. Now x-rays ionize gases through which they pass and this ionization causes a marked increase in electrical conductivity, the amount of the increase being a measure of the x-ray intensity. Hence if a reflection occurs, its presence and the intensity of the reflected beam are indicated by the increase of electrical conductivity of the gas.

X-Ray Emission Spectra

By some such arrangement, then, the composition of a beam of x-rays coming directly from an x-ray tube may be determined. This is an example of the first of the above-mentioned two types of investigation. Every angle of incidence corresponds to a certain wave-length in the beam; the presence of this wave-length and its intensity being indicated by the ionization of the gas. Such an analysis reveals the interesting fact that besides a continuous broad band of wave-lengths (the general radiation) there occur certain groups of sharp maxima, *i. e.*, certain wave-lengths are predominant in the beam. If, as is often done, a photographic plate is used instead of an ionization chamber to record the positions of these maxima, their reflections appear as sharp lines on the plate, hence they are called, simply, lines. Their positions, *i. e.*, the wave-lengths of these lines, are dependent upon and characteristic of the element used as a target. Hence these groups of lines, designated as the K, L, M, etc., series, are called the characteristic emission spectra of the elements.

Moseley's Law and the Periodic Table

It was by a systematic examination of a large number of elements, with respect to certain lines in the K series of their emission spectra, that Moseley, the young English physicist whose death at Gallipoli in 1915 brought a tragic loss to science, was able to exhibit, for the first time, a thoroughly satisfactory and consistent basis for the Periodic Table of Chemical Elements. As is well known, atomic weight failed to meet completely the demand for a non-periodic and regularly progressive atomic property for the basis of such a table. For to preserve the integrity of the chemical families in the table it was necessary in three instances (argon and potassium, cobalt and nickel, and tellurium and iodine) to place the heavier element ahead of the lighter. But Moseley's results (which have since been much extended and improved in accuracy), expressed as Moseley's Law, show that the square root of the frequency of a given line increases regularly in passing from element to element in the table. They also justified the above-mentioned reversals of atomic-weight sequences and confirmed the existence of suspected gaps in the table. Indeed, Moseley's Law has been the foundation of several recent successful attempts to fill these gaps by discovering the missing elements. For instance, Prof. B. S.

Hopkins of the University of Illinois, in his successful search for element number 61, illinium, purified his sample by fractionation until he could obtain a spectral line whose position Moseley's Law predicted accurately. More than this, the complete data of this kind now at hand preclude the possibility of the existence of a whole undiscovered family of elements, as the family of rare gases was not many years ago. Here, then, was a contribution of first-rate importance which x-rays made to chemistry.

X-Rays and the Atom

Moseley's data were also important to the Danish physicist, Bohr, when he came to develop his theory of atomic structure. Though the atom model of this theory is essentially a model for the physicist, it deserves notice here as illustrating the relation between x-rays and the atom. Briefly, then, the atom consists of a positively charged nucleus[3] and electrons revolving in orbits about this nucleus, somewhat as the planets of the solar system revolve about the sun. The nucleus is itself made up of protons and electrons and in it is concentrated the mass of the atom. The number of orbital electrons is equal to the resultant positive nuclear charge. It is called the atomic number of the element, and, indeed, this term originally meant only the position of the element in the Periodic Table. These electron orbits are arranged in groups and, as the expression is, at certain energy levels. That is, a definite amount of energy must be supplied to an electron to move it from an orbit near the nucleus to one farther away or to remove it entirely from the atom. This is the energy of which mention was made in discussing the photoelectric effect. An orbit thus vacated by the removal of its electron may again be occupied by an electron's falling from a more distant orbit into it. This transition is accompanied by the radiation of energy equal to the difference between the characteristic energies of the two levels, and these transitions very beautifully account for the lines of the x-ray emission spectra of the elements, the wavelength of the radiated energy being given by the relation, $\lambda = c/\nu$ and $E_1 - E_2 = h\nu$, where the E's are the characteristic energies of the two orbits involved and c is the velocity of light. These lines result from transitions which terminate in orbits near the nucleus, and since these orbits are similar in grouping in the various atoms, though changing in dimension as the nuclear charge increases, the x-ray spectra of the elements are all similar but change position from element to element. Thus, Bohr, whose great achievement lay in the successful coördination of apparently unrelated phenomena, found an immediate application of Moseley's data to his theory.

As already mentioned, the orbits occur in groups. In passing from element to element, and as the atom increases in size, electrons are added, roughly speaking, to orbits of the group nearest the nucleus, then to

[3] The concept of the atom as nuclear is due to Sir Ernest Rutherford.

orbits of the next group and so on. Now the chemical character of the atom is largely determined by the condition of the outermost group of orbits, *i. e.*, by the completeness with which they are occupied. It is known that the successive groups are completed when the total number of orbital electrons is 2, 10, 18, 36, 54, 86, respectively. Indeed, these are the atomic numbers of the rare gases, the completeness of their orbit groups being responsible for their characteristic lack of chemical activity. An interesting exception to the general rule of electron addition is found in the rare earths in which the addition is to an inner group of orbits, the chemical properties remaining practically constant from element to element. Thus, finally, the x-ray spectra and the chemical characteristics of an atom are seen to belong to different parts of the orbital scheme.

X-Rays and Chemical Reaction

Hence, it is not surprising that x-rays should have shown themselves inferior, in inducing and influencing chemical reactions, to other rays, *e. g.*, ordinary light or ultra-violet, which are more closely associated with the external shell of the atoms. The number of chemical reactions affected by x-rays is not large; and, with a single exception, they are not practically important. The exception is the blackening of the photographic plate. Here the action of x-rays is similar to that of light and the change is not, apparently, like some other photo-chemical reactions, *e. g.*, the oxidation of benzaldehyde, which are sensitive only to wave-lengths within a narrow region lying well outside the x-ray domain. This is fortunate, for the photographic plate may thus become the recorder of the reports these x-rays bring from their explorations into the interior of matter.

Of other reactions, it may be noted in passing that x-rays appear to have some effect upon the conversion of starch into dextrin, that they cause the inversion of cane sugar solutions, and that they have been shown to produce incipient oxidation of sulfurous acid and a reduction of potassium permanganate and iodic acid in solution. Moreover, x-rays can effect color changes in some glasses and in certain stones and minerals. In many instances these changes are not permanent, the new color fading upon exposure of the material to light. But glassware may be permanently colored and indeed artificial amethysts have been manufactured from manganese glass.

It is known, also, that x-rays can flocculate colloids, but quantitative knowledge of the process is sadly lacking. A somewhat similar situation exists with regard to catalysts. Studies of the action of radiated platinum catalysts in the contact sulfuric acid reaction reveal that at least a temporary and fluctuating effect is produced by the radiation. These studies have been, so far, merely preliminary, but they hold hope that some

genuinely important information may be revealed when they have been prosecuted further.

There remains to be mentioned (among chemical reactions) the biological effects of x-rays. Here the variables are so many and the factor of life introduces such uncertainties that a close correlation of the observations remains incomplete. The general rule may be stated that small dosages tend to activate and stimulate the functions of biological systems, and larger ones tend to destroy, either after a latent period or at once. This destructive effect has been used to advantage in combating tobacco worm larvae, the flour weevil, etc. The use of x-rays in cancer therapy depends for its success upon a nice adjustment of the dosage; the object being to damage the malignant cells while stimulating a beneficial reaction of the adjacent healthy tissue. Incidentally, too, much emphasis cannot be placed upon the fact that no modern worker with x-rays need fear the terrible physical suffering so common among the early experimenters. Through their endeavors and sacrifices we have won to a knowledge of x-rays sufficient to bring them entirely under control in this respect. Since lead is practically opaque to x-rays a lead shield is now always placed around tubes which are much used.

All these direct effects of x-radiation, the influencing of chemical reactions, the coloration of minerals, the stimulation and destruction of biological systems, would appear to be based fundamentally upon the photo-electric effect. The relationship is not always clear though. in the ionization of gases, a phenomenon already mentioned in passing, beautiful experimental evidence of the mechanism of the ionization has been obtained. Briefly, the x-rays eject high-speed electrons from some of the atoms or molecules of the gas which lie in their path, this being the photo-electric effect; these electrons then cause the ionization by disrupting additional atoms or molecules with which they come in contact. By condensing water upon the ions at the moment of their formation C. T. R. Wilson obtained actual photographs of this process. Such a photograph is shown in Fig. 3. Our quantitative knowledge of ionization itself is not yet complete, though it is being rapidly expanded, and hence the idea of ionization as the first step in these phenomena has not thus far been very fruit-

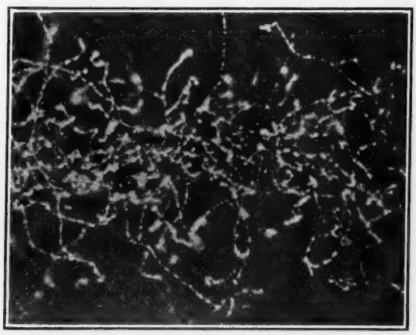

FIG. 3.—IONIZATION OF GAS BY X-RAYS

ful. But it is not too much to hope that a continued study of these chemical effects of x-rays will discover new facts about atoms and their ways of combining.

The Methods of X-Rays Crystal Structure Analysis

We have now seen what direct contributions x-rays themselves have made to our knowledge of the atom and have noted briefly how they affect atoms in the process of combining and in the completed combination. All this has followed, more or less directly, from the first of the two types of investigation using x-rays and crystals. It is now time to turn to the second, in which we send x-rays, as unique and especially equipped explorers, into the interior of the crystal, to bring out to us their report on the appearance of that otherwise impenetrable country. Since their reports vary with the conditions under which they are sent upon their journey it is worthwhile to examine briefly these conditions and the resultant information.

It has already been noted that a polychromatic beam of x-rays passed through a single crystal will give a pattern of the type shown in Fig. 2. This is the Laue diagram. The Bragg method, in which a monochromatic beam is reflected from a single set of planes of a large crystal, has also been briefly described. If the crystal is ground to a powder composed of many minute crystals, and a monochromatic beam passed through the powder, the random orientation of the small crystals ensures that all possible sets of reflecting planes will somewhere in the powder be so disposed as to reflect a portion of the beam. Since each set of planes always bends the beam through the same angle and furthermore is present, in different minute crystals, at all possible reflective positions with respect to the primary beam, the diffracted rays leave the powder in a series of concentric cones which register upon a photographic plate perpendicular to the main beam in concentric circles. Fig. 4 shows such a diagram taken through an aggregate of iron crystals. These circles are known as the Debye-Scherrer circles; the general method was discovered by Debye and Scherrer

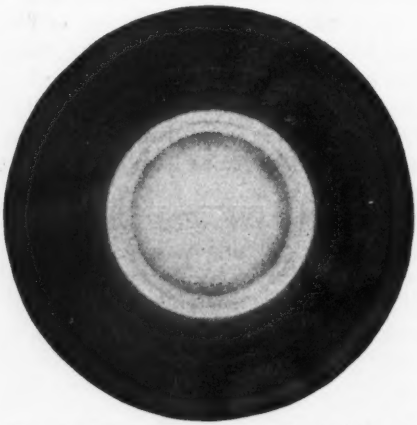

FIG. 4.—DEBYE-SCHERRER DIAGRAM OF AN AGGREGATE OF IRON CRYSTALS

and independently by Hull. They originally used a narrow, semi-circular photographic film upon which the record appeared as lines, as in Fig. 5. Again, if a single, large crystal is used in conjunction with a monochromatic beam, and the crystal is rotated about an axis perpendicular

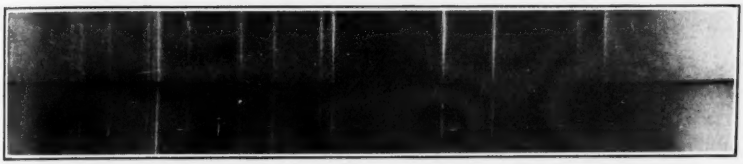

FIG. 5.—TYPICAL DIFFRACTION SPECTRUM FOR CRYSTAL POWDERS OR AGGREGATES (PLATINUM)

to the beam, various planes in the crystal have opportunities to reflect the beam at different positions in the rotation. Obviously, the result is the same if, instead of a single, large rotated crystal, many small crystals are so arranged that a certain axis of each crystal is parallel to that same axis in all the others, while the orientation with respect to other axes is random. The axis of preferred orientation then corresponds to the rotation axis of the single crystal. This is known as fibering and occurs in many natural materials. Fig. 6 is such a photograph of an almost perfect fiber of asbestos. The remaining diagrams in the article have all been taken by the monochromatic pin-hole method which is related to the powder method already mentioned. A small, cylindrical beam of monochromatic rays, defined by a pair of pinholes, is used; the specimen, however, need not be a powder, but may, in general, be used just as it comes to hand. As will be seen a wide variety of diagrams are obtained, yielding information of many kinds. These are the chief methods of obtaining diffraction patterns; others are known and, indeed, the pattern may be most remarkably changed simply by changing the mounting of the photographic film. Finally, it is possible, from the positions and intensities of these spots and lines, to

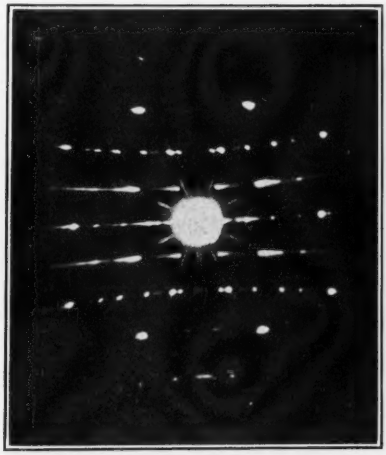

FIG. 6.—TYPICAL X-RAY DIAGRAM OF ASBESTOS

The diffraction pattern is for chrysotile. The hyperbolas upon which the intensity maxima lie are an indication of the perfection of fibering.

determine, sometimes wholly and sometimes only partially, the arrangement of the atoms within the crystal.

Results of Crystal Structure Analysis—Elements and Inorganic Compounds

What, now, are the chemically important results of these investigations? To begin with, more than half the elements and about three hundred inorganic compounds have had their crystal structures determined. These results have not, unfortunately, sustained the hope that a new and simplified inorganic chemistry of solids might be based upon them. None the less, they have furnished valuable data for the study of the interatomic forces in crystals and have been of much help in studying the properties of crystals, of which more will be said later.

Organic Compounds

The results of the analysis of organic compounds are of more direct interest to the chemist, for they offer some striking confirmations of his theories of molecular structure. Thus, among ring compounds, the structures of naphthalene and anthracene offer some interesting comparisons. The unit cells of these two compounds have very nearly the same cross section, but that of anthracene has a greater length, it being 11.6 Å. U. against 8.69 Å. U. for naphthalene. This greater length suggests, of course, the extra ring in anthracene and, indeed, Bragg found this additional length to be exactly accounted for by assuming the closed ring of six carbon atoms known to exist in diamond and graphite to be carried over directly into these ring compounds. The unit cell in each case contains two molecules set as mirror images to each other. The cross section remains constant because it depends not upon the number of rings but upon the breadth and thickness of a single ring.

Upon the aliphatic, or long chain compounds, an enormous amount of work has been done and new results are being published with almost confusing rapidity. This is the more noteworthy since the experimental difficulties have been great, the lower members of the homologous series being liquid at ordinary temperatures, and the higher ones being difficult to prepare pure and in single crystals. Paraffin hydrocarbons, aliphatic acids, esters, soaps, and ketones have been studied. The results show these substances to be truly crystalline and to preserve, throughout a series of homologous compounds, a constant cross-sectional area of the unit cell, while the length of the unit cell increases steadily in going up the series. The acids are divided by these measurements into two series, those with an even number of carbon atoms falling on one straight line, those with an odd number upon another when number of carbon atoms is plotted against the length of molecule. This agrees with the well-known fact

that in an homologous series the melting points progress alternately depending upon even or odd numbers of carbon atoms. The increase in length per CH_2 group for the odd series is 1.22 Å. U., for the even, 1.07 Å. U. For esters the increase is 1.22 Å. U., for soaps, 1.3 Å. U., and for ketones, 1.3 Å. U. This difference in increase is due to the fact that the x-rays measure the perpendicular distances between the ends of the unit cells, to which the molecules may be at different inclinations. Recent studies show indeed that the acids, at least, may crystallize in as many as three different modifications depending upon the method of preparation; the difference lies probably in different inclinations of the molecules to the base of the unit cell. For the ketones it is possible to decide upon the position of the ketone group, and alternative formulas may be tested; thus of C_nH_{2n+1} and $C_nH_{2n+1}CO.C_mH_{2m+1}$, the second is shown

$$C_mH_{2m+1}\diagup\!\!\diagdown CO$$

to be correct.

Finally, we see that the long chains of the organic chemist have, by means of x-ray crystal analysis, come to a definite reality. The atoms in these chains are staggered along the center line of the molecule and in the most recent work it has been possible to come very close to the actual positions of these atoms along the chain. Though this is but the briefest summary of our present knowledge, as the experimental technic is more and more developed we shall undoubtedly have still more and interesting information for the organic chemist, who may hope to find, in fields as yet unexplored, new knowledge of the structure of his compounds.

The Properties of Crystals

All the results of crystal structure analysis have brought forth certain facts of great interest to chemists. In the sodium chloride model already noticed it is seen that the molecule, NaCl, has lost some of its identity in the crystal, for any atom of the one kind belongs equally well to all six of the atoms of the other kind equidistant from it. Such is not always the case, however, and we find certain radicals, for instance, the $CO_3^=$ and $SO_4^=$ evidently retaining their configuration intact in different salts. Here, of course, the oxygen atoms belong definitely to a particular carbon or sulfur atom. In organic compounds, as we have noticed, the molecules most definitely appear as such in the unit cell. Since, in this case, the forces binding the molecules cannot begin to compare with the strong forces holding atom to atom, these substances melt or sublime very easily.

The results of crystal analysis have also verified Werner's theory of valence, both for the primary and secondary valences. Thus Werner's postulate that in $Ni(NH_3)_6Cl_2$ the six ammonia molecules should be held

around the central nickel ion at the corners of an octahedron has been verified by x-ray analysis.

Of the physical properties of the crystal which can be studied by and related to the crystal structure the rotation of the plane of polarized light is perhaps of most interest to the chemist. All crystals which show this property have a spiral arrangement. Thus the *d*-tartaric acid has, in the crystal, two spirals, one due to the molecule and one due to the placing of the molecules in the crystal unit. The rotation is determined by the net effect of these spirals; in solutions, of course, the second spiral is absent. Also sodium chlorate crystals are optically active due to the crystal formation; the activity disappears in the solution.

Ductility, compressibility, and elasticity are other physical properties which are directly related to crystal structure. For the chemist it is interesting to note that a study of crystal structure and its symmetry relationships can afford information as to molecular symmetry, stereoisomerism, and polymerization.

Metals and Alloys

Undoubtedly x-rays have been directed more to the study of metals and their alloys than to any other class of materials. Here we can only note the most important results. First, the allotropic modifications of several metals, notably iron, cerium, cobalt, and tin, have been examined. Three modifications of iron are found, there being no x-ray evidence for β-iron. Studies of allotropy under unusual conditions of temperature and pressure have not yet been carried out, but they may be expected to yield much new knowledge.

Some definite inter-metallic compounds have been reported. Thus, for instance, NiAl has a body-centered cubic lattice in contrast with the face-centered lattices of the pure metals. Many alloys have also been examined and, without discussing the details, we may note the general results. Solid solutions, then, are of two kinds. In the first, or "substitutional" kind, the solute atoms go into the lattice of the solvent atoms. The substitution generally is random, or statistical, but in some cases at the composition corresponding to AB_3, AB, A_3B a definite arrangement of all atoms occurs. The other, or "interstitial" solid solution has the solute atoms set within the lattice of the solvent atoms without disturbing it beyond an expansion. Such arrangement generally arises when the alloy is of a metal and a light atom, as, for instance, iron and carbon. Of the particular alloys the iron-carbon alloy is, of course, of the greatest interest both because of the practical importance of steel and because of the complexities and uncertainties of the phase diagram. It must be confessed, however, that x-ray studies have not as yet effected much simplification.

Although the results of working and annealing metal lie, perhaps, outside the strict boundaries of chemistry, they are so interesting that several typical x-ray diagrams of metals are presented in Figs. 7 to 12. These diagrams with their captions are largely self-explanatory. By such diagrams it is possible to judge the average crystal grain size; whether fibering, *i. e.*, preferred orientation of the grains, exists; whether, for a given specimen, the proper annealing has been applied, etc. Thus these x-ray diagrams of metals become of great importance and it is to be expected that the specifications for metals, at least for certain uses, will soon include an x-ray diffraction specification.

FIG. 7.—STRUCTURE OF ALUMINUM WIRE

The view is a fiber diagram of a cold-drawn aluminum wire that was subjected to various annealing treatments and followed by a measurement of tensile strength and the making of x-ray diagrams.

Colloidal and Amorphous Structure

The extension of the x-ray diffraction investigation to all sorts of solid materials has greatly modified our ideas of the solid state and crystallinity. Many substances apparently not crystalline have indeed been shown to be so, the crystal grains being so minute as to escape ordinary detection. At the same time the boundary between crystalline and amorphous matter has been broadened and graduated. Thus, between the three-dimensional regularity of arrangement of the true crystal and the complete randomness of arrangement in the amorphous state, there are the mesomorphic or intermediate states in which the molecules begin to orient themselves. These changes show themselves on the x-ray patterns, an amorphous material giving one or two diffuse rings, and the other states diffracting according to their degree of arrangement. It is now generally accepted that the amorphous ring is a measure of the closest approach of the molecules in the amorphous substance. There have been remarkably few solid substances which give a purely amorphous diagram. Metallic potassium at ordinary temperatures, unstretched rubber, and perhaps some carbon blacks do so.

Thus we have here, also, a means of examining colloids, and they are found to have structures ranging all the way from crystalline to amorphous. Colloidal metal sols usually give the diffraction pattern of the

large crystal, except that the lines increase in width as the particle size decreases. This may indeed be used as a measure of particle size, when the particles are on the average less than 10^{-6} cm. in diameter, and a formula relating line width and particle size has been developed.

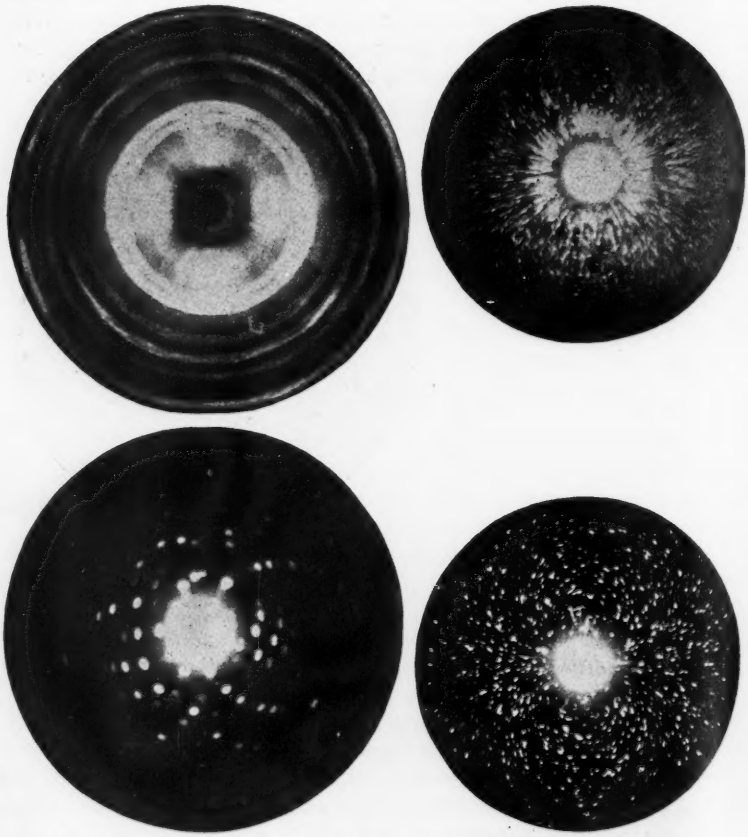

FIG. 8.—DIFFRACTION PATTERNS OF A SERIES OF SILICON-STEEL SAMPLES

The samples represent steel suitable for electrical construction and differ essentially in the annealing only. The upper left view shows the original structure of the rolled steel before annealing; the upper right, a partial or unsatisfactory anneal showing a high hysteresis loss; the lower left, a controlled anneal showing a low hysteresis loss; and the lower right, an anneal and subsequent straining such as is introduced in a punching operation.

Probably the most interesting colloidal researches have been upon rubber and cellulose, to mention only two of the more important of a large number of materials. Ordinary unstretched rubber gives an amorphous diagram, as in Fig. 13. When, however, the rubber is stretched its dia-

gram becomes distinctly a fiber diagram, as in Fig. 14. Here, then is a case where the act of stretching induces some kind of an orientation or crystallization. The evidence is that these crystals do not exist before the stretching. The mechanism is supposed to be something of the following: large irregular molecular aggregates exist in the ordinary rubber; upon stretching these aggregates shrink and contract bringing the molecules into a regular position. Some measurements have been made of the unit cell of rubber but as yet the agreement upon the size and the number of molecules of C_5H_8 per unit cell is not good. Here again the door has hardly been opened and there can be no doubt that x-rays have still much to tell us about rubber.

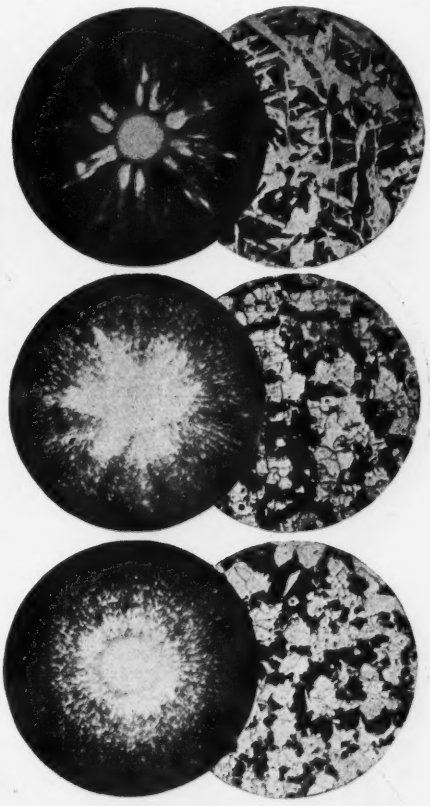

FIG. 9.—PRACTICAL IMPORTANCE OF THE PIN-HOLE METHOD FOR X-RAY DIAGRAMS

The top diagram and photomicrograph are those of cast steel as cast; the middle view is for cast steel after 5 hr. of annealing treatment; and the bottom view is for cast steel after four 5-hour anneals. The coarse non-uniform grain-mass of steel as ordinarily cast, shown in the top view, is by no means obliterated in the standard annealing processes, as the middle view indicates. The removal of internal stresses is not impossible under proper annealing conditions. The ideal structure of small equi-axed crystals with neither directed orientation nor internal strain is shown in the bottom view for the same casting.

Cellulose fibers also have been studied; not only the natural fibers, but the various rayons as well. All cellulose, except the diacetate rayon, has given crystal patterns; the amount of fibering, however, varies widely. Figs. 15 and 16 show two of these patterns. Silk, wool, and other textile fibers have been examined and x-rays will doubtless soon be turned to the study of dyes and their applications to these fibers.

Liquids also produce diffraction effects, the pattern consisting of one or more amorphous rings. Though it appears that the spacing corresponding to the amorphous rings is probably a measure of the average distance between molecules, the factors influencing diffuseness and complexity of the

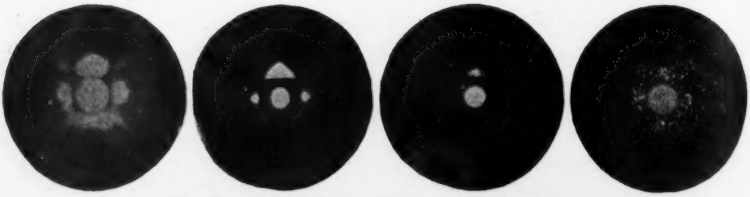

FIG. 10.—SHEET-STEEL DIFFRACTION PATTERNS

The patterns were obtained with ordinary low-carbon sheet-steel after hot and after cold-rolling. The hot-rolled-steel pattern appears at the extreme left and the cold-rolled-steel to the right of it. The two views at the right illustrate variations in the same sheet of rolled sheet-steel after annealing.

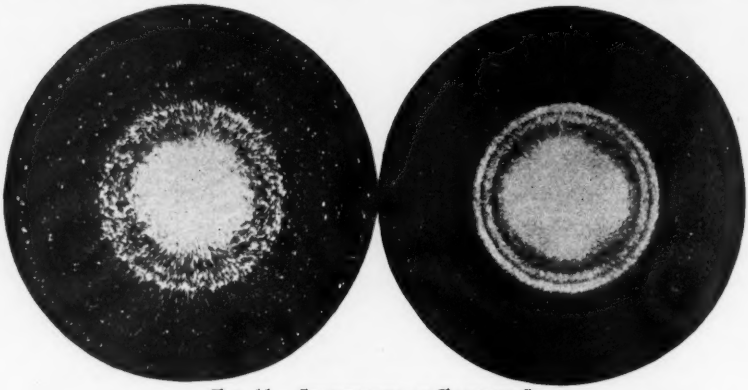

FIG. 11.—STRUCTURES OF FORMING STEEL

One of the great metallurgical problems at present is a satisfactory test or method of prediction of the behavior of steels in forming. Photomicrograph and physical tests may often be identical for two sheets, yet one will crack in forming while the other easily withstands the strain. X-ray diffraction patterns of such a pair of sheets are shown, the satisfactory sheet being represented at the left and the unsatisfactory sheet at the right.

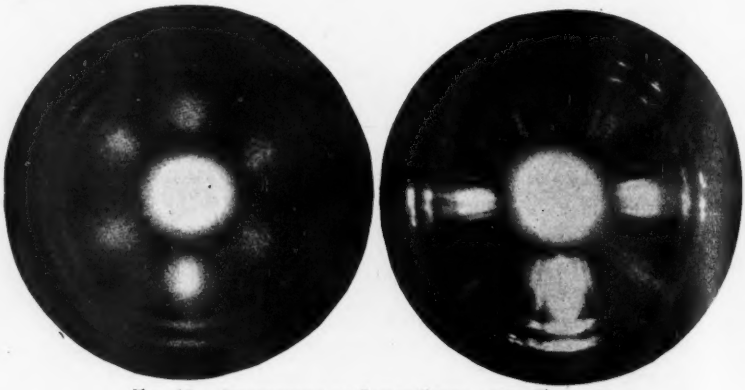

FIG. 12.—STRUCTURES OF SHEET STEEL AFTER FORMING

Satisfactory structure is shown at the left and unsatisfactory structure at the right. A very sensitive method is required because the photomicrographs may appear to be identical.

diagram are not yet well understood. However, recent work indicates that a study of these patterns may well yield important information about the liquid state.

Thus we see that in the thirty years since their discovery x-rays have

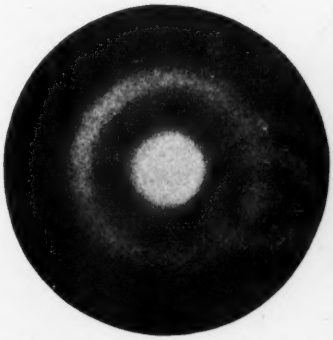

FIG. 13.—PIN-HOLE DIFFRACTION DIAGRAM FOR UNSTRETCHED RAW OR VULCANIZED RUBBER

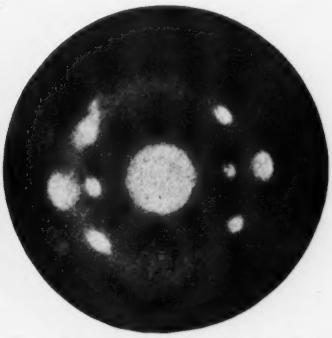

FIG. 14.—PIN-HOLE DIFFRACTION PATTERN FOR STRETCHED RUBBER

told us many things about many subjects, at most of which we have here had time for only a passing glance, and at some of which we have not looked at all. Thus, no mention has been made, for it lies outside our field, of the most widely known use of x-rays, radiography, which is now so common that its use to locate broken bones, bullets, etc., is fully expected. But, far as x-rays have already taken us on our search into those branches of architecture where atoms and molecules are the building stones, we have just begun; and new knowledge of both theoretical and practical importance will continue to open out before us on every side. The truly great achievements of x-rays in chemistry lie, not in the past, but in the future.

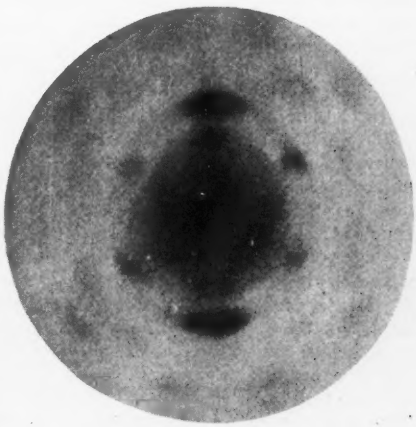

FIG. 15.—DIFFRACTION PATTERN OF RAMIE FIBER

In conclusion, I can only hope that this will serve as an introduction between this fascinating science of x-rays and those readers who have not before had the time or opportunity to make its acquaintance and who, though they may never press the acquaintanceship further, will none the less have been glad of the opportunity for the meeting. I am deeply indebted to Prof. G. L. Clark, until recently of this Institute and now of the University of Illinois, at whose suggestion I undertook the preparation of this paper, whose book, "Applied X-Rays" has been my guide throughout, and who has given me many valuable suggestions.

FIG. 16.—DIFFRACTION PATTERN OF SISAL FIBER

Hieroglyphics Reveal Origin of Chemical Terms. The word chemistry and the names of such chemical materials as toilet articles, perfumes, dyes, textile fibers, precious stones and metals have been traced back to an Aryan source by Dr. W. R. Kokatnur, consulting chemist of New York City.

Speaking before the American Chemical Society meeting in Detroit, Dr. Kokatnur cited hieroglyphic records as well as archeological and ethnological evidence to support his conclusions concerning the origin of chemical terms.

The isolation of metallic mercury dates back farther than many historians have believed, Dr. Earle R. Caley declared, speaking in the same division devoted to the history of chemistry. Apparently the only compound of mercury known to the ancients was the sulfide. This was used as a pigment and early Roman writers have left accounts of a chemical test to detect its adulteration.—*Science Service*

Open-Weave Cloth Transmits Ultra-Violet Rays. To be bathed by the beneficial ultra-violet rays, wear open-weave fabric.

To test the claims that artificial silk cloth allowed large amounts of the health-giving, short wave-lengths of sunlight to pass through, various fabrics were submitted to test at the National Bureau of Standards. Cotton was found to be nearly as transparent to the ultra-violet light as viscose and cellulose acetate, and real silk had about the same transparency as cotton. The viscose artificial silk was more transparent than that made from cellulose acetate but the maximum transparency measured was only 27 per cent. Dyes or the yellowing due to age was found to reduce the transmission to only about 5 to 10 per cent and in most fabrics the threads occupy 95 to 99 per cent of the total space.

The experts concluded that the composition of the fabric is of less importance than the coarseness of weave.—*Science Service*

KARL FRIEDRICH MOHR

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The chemical control of industrial processes rests largely on volumetric analysis. This division of analytical chemistry was initiated by Gay-Lussac who introduced titration "as a purely technical operation for the estimation of the value of soda and pearl ash." The advantages of analysis by measure were obvious, and, although numerous methods were devised for various purposes, progress was impeded by the lack of convenient measuring apparatus. The Gay-Lussac burette was not easy to manipulate and frequently its use did not lead to results of high accuracy. The inventive genius of Mohr seized upon this problem and he not only proposed practicable modifications for improving the original instrument, but designed a much better burette which, bearing his name, is used today in the original form. The various types of pipettes are largely due to him. The pinch clamp, the cork borer, the automatic burette, a rapid dialyzer, the specific gravity balance, gas generating apparatus and gasometers, an automatic device for washing precipitates, goggles for dangerous experiments, a fume hood for domestic laboratories; all these and other devices testify to his inventive talents. He was an adept in devising new volumetric procedures; he tested, criticised, and frequently improved the proposals of others. The general adoption of the normal system of standard solutions is largely due to his ardent advocacy. This use of equivalent weights was probably first proposed by Joseph Griffin, but it did not find favor among chemists who preferred to employ solutions reading percentages, even though this necessitated a different solution for each material analyzed. Mohr's greatest service was his compilation of all the trustworthy methods so widely scattered throughout the literature, under a uniform system in his well-known text, "Lehrbuch der chemisch-analytischen Titrir Methode." This appeared in 1855 and ran through ten editions. Its popularity was widespread and this book, probably more than any other factor, was responsible for the general adoption of titration methods. In view of these services, Sutton says: "He may with justice be called the father of the volumetric system."

Karl Friedrich Mohr[1] was born in Coblenz on November 4, 1806. He received his early education at home, passed eight years at the local gymnasium and evidently spent much of his time in his father's pharmaceutical establishment learning manufacturing and analytical methods. After three semesters at Bonn, devoted to botany, physics, chemistry, and

[1] Three generations of the family bore the first name Karl, and the subject of this paper signed himself Friedrich, or frequently simply Dr. Mohr, to avoid confusion with his father or his son. In the catalog of *Scientific Papers* issued by the Royal Society, the publications of all three are ascribed to Friedrich. His papers number well over 200.

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L. Mohr

mineralogy, he enrolled at Heidelberg and specialized in chemistry under Leopold Gmelin. As a result of a brilliant examination, he was awarded his doctorate "summa cum laude" in 1832. The examiner in mathematics commented: "The candidate shows an unusual knowledge of mathematics for a pharmacist." The next two years were spent in study at the universities of Berlin and Bonn and in 1834 he returned to Coblenz to take an active part in his father's business. Mohr wrote: "When the time came to choose a profession, I decided that after I had mastered pharmacy, I should satisfy my predilection for the natural sciences and actively pursue them whenever I had the opportunity." This resolution was carried into effect and most of his scientific work was done under these conditions. His scientific enthusiasm and the fervor of his inward conviction that the things of interest to him should also be of use to others gave him a decided pedagogic bent and soon after his return home he delivered, with great success, a course of popular lectures on chemistry and physics.

His investigations in chemistry and pharmacy soon earned for him a widespread reputation and he was recognized as the leading scientific pharmacist of Germany. In 1837, after the death of Geiger, professor of pharmacy at Heidelberg, Mohr took up the task of finishing the *Pharmacopoeia universalis*, a great work not completed until 1845. His excellent text on pharmaceutical technic was published in 1847; a commentary on the Prussian pharmacopoeia appeared the same year, and both ran through many editions. His father died in 1841, and Friedrich took over the business, conducting it with success until 1857 when he sold it and retired to his country estate. He now busied himself with a scientific study of agriculture, fermentation, and methods of combating the diseases then ravaging the vineyards. Two books on the growing of grapes and preparation of wine were published in 1864.

Mohr had always been in comfortable financial circumstances, but in 1864 he lost almost his entire fortune through the failure of a vinegar and pharmaceutical factory whose management had been entrusted to his son-in-law. Not discouraged by this blow, Mohr, now almost sixty, philosophically considered the catastrophe as a turn of fate, compelling him to take a step in the direction toward which he had always been inclined. He decided to actively enter the teaching profession. He received a license to lecture in the university at Berlin, but he and his wife were so dissatisfied with living conditions in the large city, the resources in the chemical laboratory were so meager, and the competition so keen, that he never delivered a lecture there. He became *Privat dozent* at Bonn, with license to lecture in chemistry, pharmacy, geology, and mineralogy. This array of subjects testifies to the wideness of his knowledge and interests. The licentiate examination was a mere formality, as the examiners knew Mohr was their superior in their own fields.

Geology now claimed most of his attention; he advanced new revolutionary ideas in that field, often becoming extreme in his conjectures. He flayed his critics unmercifully and the enmity engendered by these attacks lasted to his death. He studied geological phenomena with a fullness of chemical information, possessed perhaps by no other geologist of his time, and he never hesitated to indict his antagonists for their ignorance of chemistry. His history of the earth, published in 1866, was widely read. Many authorities believe he had no lasting influence in the development of geological philosophy, but his zeal, like that of many another intelligent, though mistaken, revolutionary was probably not entirely in vain.

In 1867, he began to seek an explanation of chemical affinity, being led into this field by the catholic viewpoint from which he considered geological phenomena. He based a theory of regelation on the mechanical theory of heat which, though not new, was a product of his own views, since he had little if any acquaintance with the work of Mayer, Helmholtz, Joule, and Faraday. When accused of this apparent plagiarism, he studied the papers of these authorities and then recollected an article he had published and forgotten in 1837. He confesses, "Only now do I realize that the views I expressed thirty years ago contain the characteristic features of the mechanical theory of heat." The passage reads, "besides the 54 known chemical elements, there is in the physical world one agent only, and this is energy. It may appear, according to circumstances, as motion, chemical affinity, cohesion, electricity, light, heat, and magnetism, and from any of these forms it can be transformed into any of the others." His book, "The Mechanical Theory of Chemical Affinity" shows his lack of preparation in this field, but it served as a protest against the worship of formalism then dominating chemistry and called attention to the necessity of considering the fundamental ideas of chemical philosophy. Some credit is due to Mohr, but his ideas were so visionary, in contrast to those of the men mentioned above, that the inscription on his tombstone, "First Discoverer of the Law of the Conservation of Energy, 1837" is certainly open to criticism.

Be that as it may, there can be no doubt as to his accomplishments in chemistry. Mohr's outstanding contributions to analytical chemistry include his method for volumetric determination of chloride with standard silver solution in presence of chromate; the introduction of oxalic acid and ferrous ammonium sulfate (Mohr's salt) as primary standards; the protection of solutions from the action of the air by covering them with a layer of mineral oil; the Mohr liter; and a whole host of analytical procedures which, if now superseded, served the needs of the time and in many cases formed the basis of present-day methods. He was an adept at chemical calculation and some of his indirect analyses were extremely ingenious. In 1860 he published in the *Annalen* an offer of a carefully

calibrated burette for the first correct solution of the problem: "Devise a volumetric procedure which will involve no weights and no standardized solutions." The replies were published and Mohr naively admitted that he had forgotten that the problem had been proposed and solved in the first edition of his textbook. He had no sympathy for writing that was unnecessarily involved. In one of his letters he wrote: "The greatest fear of some 'scholars' is that their utterances may be too easily understood and that they, therefore, may appear to be of this world. A sure sign of this is the use of integrals on the second page of a treatise. When an ordinary man would say 'I light a cigar' these learned persons of the first rank declaim 'Let the cigar be φ and myself ϕ. In so far as I light the cigar, I am a function of φ and the flame is the exponent. Therefore, this act may be written as the equation, $\phi = f\varphi^m$. What is the net result? The 'scholar' simply smokes his vile cigar."

The most interesting chapter in Mohr's life was his intimate friendship with Liebig. Its beginning is not known, but it was probably founded on a mutual admiration of abilities. Liebig respected Mohr's practical talents, his active intelligence, and his scientific spirit. "It is remarkable what one man of intelligence and inventive talents may accomplish for a science, and how often a whole series of advancements is due to and depends upon a single person. Thousands have sublimed flowers of benzoin, one like the other, and not one, except the first, thought about the matter. Now you repeat the process, again contributing some thought, and the result is a new perfected procedure." In another letter Liebig writes: "In your hands chemical apparatus immediately takes on another form; it is surprising how little aptitude for such things is evidenced. The burettes of Gay-Lussac, etc., have been modified by others but without real improvement. They were just different, involving no new ideas." Frequently Liebig submitted new ideas to Mohr and had a high regard for his opinions. "I wish you had been my father" perhaps sums up Liebig's opinion of his friend.

On the other hand, Mohr was Liebig's first convert to many of his revolutionary doctrines and Mohr became his most ardent protagonist, defending and spreading his friend's teaching in agricultural and medical circles. It was only natural then that Mohr should expect Liebig's support when he was being attacked for his heretical geological notions, but Liebig refused to prostitute their friendship by defending views which he neither understood nor adhered to. "How falsely you judge me, if you believe that any difference of opinion with you could have any influence on me; opinions are based on assumptions which are changeable, and no intelligent man can expect that his views will be valid forever. All my opinions have changed, but not so with my facts. These I defend with my blood if necessary." Convinced that Liebig was not to be moved

from his position, Mohr published a glowing article in praise of his friend and then wrote to him, "Now you cannot write anything in praise of my teachings, for it would only appear to be reward for my praise of you."

Mohr was a frequent contributor to Liebig's *Annalen* and, noting the quality of his work and appreciating his wide knowledge, Liebig proposed that Mohr become co-editor of this journal. However, the arrangement did not work well. Mohr did not view the position with the same seriousness as did Liebig and after some frank letters of criticism, followed by ineffectual efforts on Mohr's part to give satisfaction, it was announced that the duties of editing the *Pharmacopoeia universalis* would not permit Dr. Mohr to continue as co-editor of the *Annalen*.

THE GRAVE OF FRIEDRICH MOHR

The friendship was not interrupted, the families visited each other and Liebig felt no hesitation about asking Mohr to run all sorts of errands for him. "Please send me two dozen steel pens," or "Go to the hotel and ask about a pair of slippers I left there," are typical requests. Mohr had won the favor of some of the ruling house of Prussia, and Liebig requested him to present the princess with one of his books, so that he, too, might possibly bask in the royal sunshine. Mohr was glad to do this. When Mohr's financial crash came, Liebig offered him money and also did his best to secure a teaching position for him. Material aid was willingly proffered, but as related above, Mohr could not expect professional support in views of the validity of which Liebig was not con-

vinced. The latter once wrote, "With me it is never a question of persons, but only of the cause which I pursue; I have always a definite purpose which I seek to accomplish."

Mohr's fiery character was constantly leading him into bitter debates, from which personalities were not always excluded, but in his relations with Liebig he seemed to be willing to endure all things. Their friendship lasted more than thirty-five years. Much of their correspondence has been preserved and makes most interesting reading. Liebig constantly counsels Mohr to subdue his martial nature. "Don't strike the people in the face if it is not necessary. Let the facts themselves strike home—" "State new ideas but do not throw stones at the older notions. Rejoice that you have been successful where others have failed, but give what you have to offer with a cheerful countenance. You speak of your views as a lover speaks of his sweetheart, but lovers are notoriously incompetent judges of the objects of their affections." Realizing it was no use, he finally wrote, "You still have too much of the fire of youth for me to hope that you will heed my words." Mohr did not take the advice and when he died on October 5, 1879, his enemies were still numerous and active. Little note was taken of his passing, and not until 1899, when part of the Liebig letters were published, was his memory rescued from the partial oblivion into which it had fallen.

German Doctor Develops New Diabetes Treatment. Another diabetes treatment has been announced. Dr. Karl von Noorden, professor of medicine at the University of Frankfort, reports a new substance for the treatment of diabetes which he calls "glukhorment" made from the pancreas by a process of fermentation. It has the practical advantage over insulin of being given by mouth rather than by injection and clinical tests of the new preparation are being awaited with interest in medical circles.—*Science Service*

Pasteur Institute Receives Gift. A legacy of 20,000,000 francs or approximately $800,000 has just been left to the Pasteur Institute by a French physician, Dr. Rene Marius Appert of Paris, according to a report received from the Paris correspondent of the American Medical Association.—*Science Service*

"Wrought Iron" in Meteors. The metallic part of stony meteors, which sometimes fall to the earth from the heavens, is very similar to ordinary wrought iron, made artificially. This was reported to the National Academy of Sciences recently by Dr. George P. Merrill, of the U. S. National Museum. Dr. Merrill is the leading American authority on the composition of meteoric materials.—*Science Service*

Germans Would Use Alcohol for Burns. That absolute alcohol by the gallon should be kept on hand in chemical plants as a remedy for burns is recommended by a German chemist, according to a report to the American Chemical Society.

Pure alcohol has been found to be a particularly efficacious treatment for the severe burns that result from contact with sulfuric acid and other strong reagents used in industrial chemical processes. The quicker the cases are treated the more effective are the results. Blisters never develop, it is said. Due consideration must, of course, be given to possible risk from the inflammability of alcohol, the correspondent points out.—*Science Service*

THE PREPARATION OF PLANT ROUTINE CHEMISTS AND CONTINUATION EDUCATION*

G. B. AND R. E. ROSE, E. I. DU PONT DE NEMOURS AND CO., WILMINGTON, DELAWARE

Education is the conventional mastery of the huge mass of facts, manners, and beliefs that has accumulated through all the ages and is stored in the written records and the inherited memories which together we call the experience of the race. Plutarch, today, would be very far from possessing a knowledge of the great bulk of facts which we consider necessary to a comfortable, useful existence. The newsboy at the street corner is very much better informed than Plutarch. However, we consider the newsboy uneducated and the Greek gentleman educated. What, then, comprises education in our modern civilization? To the great mass, educated is a word indicating that the person to whom it is applied has passed through a series of years in high school, college, or university. Unfortunately, we are far less critical in our use of words than we should be; less critical in our thinking. It is this fact that causes us to give little or no credit to the man of high mentality who, though without a formal education, may be more truly educated than the college graduate who frequently, although he has complied with the forms, is grossly ignorant and poorly educated. We credit the material success of the man who has no formal education but we always look askance at his culture simply because we consider the form instead of the spirit.

This introductory statement is made to emphasize the fact that education is not entirely a matter of conventional procedure.

The child psychologist tells us that the most important two years of life are the first two. During the pre-school age, that is up to about five years, the education of a child is like that of other children only to the extent that his parents and his surroundings are similar to those of others. It is during that period that the progress of the child depends very greatly on the ability, the education, the interest, the broad-mindedness, and the material prosperity of his parents and for this reason we have, during this period, very wide differences in the type of training acquired by the child who may be the offspring of illiterate immigrants or the well-nurtured child of the better classes, or possibly the infant prodigy who does complex mathematical problems in his head or beats his elders at so intricate a game as chess.

Following this more or less individualistic period come seven or eight years of adherence to an educational program which is common to the whole population. It has for its object the acquisition by the average citizen of the essentials of reading, writing, and arithmetic, the reading

* Presented at the A. C. S. Institute of Chemistry, State College, Pennsylvania, July 13, 1927.

including spelling, a little history, and a little geography. Unfortunately, such is our present limitation that when the boy and girl get through they remember much more vividly those experiences which they have had outside the school, and they are much more sharp-witted in those matters which they have had to master because of their competition with their fellows than in those which they have been required to know to meet the essentials of the school-room. At the end of this period, at the present day, the average boy knows quite a lot about wave-lengths, electrons, carbureters, and aeroplane compasses, information which he does not get in school, but information which will stick to him throughout life. This is not said to disparage the value of what is acquired during the school period, but to emphasize the fact that the school does not play the most important part in the development of a child's life but merely rounds out his experience, gained by contact with life, in order to prepare him for the future.

The high-school years come and go; essentially a continuation of the grade school. More courses, treatment which is perhaps a little less individual, more subjects, and a method of presentation which grows stiffer and, therefore, in a good many cases, extremely uninteresting, make the main object during the high-school years, even to a greater extent meeting the requirements of the teacher, without interest in the subject while learning all one can of one's fellows in athletics and in social contact outside the class-room. Unfortunately, without a story teller for a teacher, English history must necessarily be little better than a dry subject. Kings and queens of England pass before the students always more as words on paper than anything else and the great pageant of the past never appears. That is why years afterwards there is no more than a dim memory of having heard about some rather uninteresting people who lived and died a great many years ago. On the other hand, think how vivid is your recollection of those occurrences which touched your own personal life; your feelings after having smoked your first cigar; your pride in your first long trousers.

The elect, by dint of their own perseverance or by virtue of the support given them by their parents, go to college and their formal education continues for another four years. At the end of that the student expects his training to be over, expects to find himself a man in a man's world, able to shoulder his share of the world's burden and to call himself educated.

Alas, when you come to check up, struggling as you are in the new world away from all formal instruction, formal care, you look about and you find to your great discouragement that the youngster who quit high school in the second year because he could not be bothered with the drudgery of class work, the workman's son who never even went to high school, are drawing more pay than you can persuade anybody to give you. This

is rather a startling and a very painful discovery unless one looks into it and understands the meaning of the fact. An overwhelming majority do not go beyond the eighth grade. Do they then cease to share in an educational process? Were they failures? Not at all. As a matter of fact at twenty-three they are capable of rendering service to the community which is worth more than the service of the fledgling college graduate. Obviously their development has not been arrested. They are actually mentally more mature than the college graduate, that is, maturer in the sense of being in harmony with their surroundings. This statement is intended not to slight the university graduate, but to draw attention to the fact, fundamentally important to our present discussion, that the enormous industrial organization of this country is by far its greatest educational institution and that it is this institution which has eventually to make the citizen valuable. It is this institution which takes in hand those boys and girls who do not go to high school or who do not go to college and makes them valuable enough to receive more pay than the college graduate just after his academic work is completed. In our present civilization millions of young people get their education from the industries. They learn their advanced arithmetic in an accounting department; they learn their specialized physics in a mechanical department; they learn their geography in a shipping department; they learn their English and grammar because of the responsibility they have in taking dictation. If they are placed in positions of confidence they have to learn quite a little of the special line which the man employing them follows. If they are secretaries to a chemical director they must certainly learn something of chemistry by contact, at least. Systematic filing, designing, metal working, applied electricity, all these and others too numerous to mention, are given as courses by industrial concerns and the courses are founded on the proper relation of the learner to the teacher. It is the learner's bread and butter and he must learn if he is to get on. The teacher has no soft heart but moves with the deliberate demand for efficiency which is characteristic of constructive growth. But we must not take it that industry is exploiting the population. After all, the formal education of the children of this country is an enormous tax on the population and it must not be considered that the informal industrial education is any less costly. It is the industry which pays for the mistakes made by those who are learning, for the long period of training which may often be unproductive, and, in addition, pays for the maintenance of the health and the material support of the individual who, for the first time under such influences, learns the real meaning of the value of the dollar.

It is the industry which supplies the maturer person to act as teacher to educate the young by a process of trial and error, the very best type of lecture, laboratory, and quiz work; and yet so curious is our attitude

which perhaps has come down from the days of scholasticism, that we cannot think of education as apart from the four walls of an institution and he who is a part of the formal system is very apt to slight all outside enlightening agencies and class those who rely on them for their development as being barbarians and Philistines. The academic attitude is still that of a priesthood whose requirements spell the difference between education and ignorance.

Having regard not alone for the capacity of the individual for production but also for his capacity to fit into society (because now the big industrial organization is just as particular about the personality of its employees as of their capacity to do work), the industrialist considers the young college graduate extremely immature. He knows that the high-school graduate, or the college graduate, will have to go through a long, sometimes a very long, unproductive training period, during which time the employer sees to it that the beginner is given a chance to find his place in the organization. The beginner becomes productive (and this is true of the chemist whom we are here to discuss as well as any other professional man) only when he grows to be a product of academic book learning merged with the results of practical experience; when his college training has grafted upon it that broadened, more intense training which alone makes it possible for him to learn the proper application of his knowledge to the problems of life.

In other words, in this period of life, too, the formal education cannot be considered the all-important part—it is merely the introduction. One in the industry cannot fail to regard the chemist who has not alone the academic but the practical side to his credit as being a much more fully developed human being than were he not brought into contact with the industry. We do not feel that he is to be pitied, we feel that he is to be congratulated on what he has learned in addition to his academic attainments.

With this evaluation of pre-industrial formal education and industrial experience we may now consider our specific subject, the training and continuation education of routine chemists. Bearing in mind what they do and what they should be able to do, let us ask whether, during the period of training, those men who become routine chemists should have had a specialized course. Remember that we are talking now of those who have no less than the equivalent of a college training. For our purpose, unless they have that equivalent, we cannot consider them chemists, they are simply laboratory boys with a little information that makes it easier to give them instruction, but still an insufficient foundation to be routine chemists, able to direct work or carry out independent work. And here let it be stated that the word "routine" as applied to the chemist is misused and grossly misused. It is considered disparaging and it ought not to be. The routine chemist

may be an astonishingly useful unit in an organization and his work, though differing from that of the research chemist, is no less dignified, no less important, and calls for no less ingenuity. Moreover, the routine chemist, if he is employed in a small job, is simply there during a transitional period if he is capable of growth and the larger responsibility into which he may grow is just as likely to be a plant executive position or a research position as any other. Therefore, throughout this paper the word "routine" is used bearing these facts in mind and we wish to protest against its use in any other sense. However, with the conventional meaning attaching to it, to specialize in routine chemistry is enough to dampen the ardor of the most ambitious. How is anyone to tell at the college age whether he will be a routine man, a research worker, or a good plant man? It simply cannot be done and to choose what is conventionally, although not actually, the minimum possibility, that of being a routine man, is to admit oneself a failure at the start. Only when he comes into contact with the actual requirements will he know which particular type of work is most attractive and which he is best fitted to do. Only if he fits into his work so well that he can put his whole soul into it can he realize his possibilities. He who is compelled to do what he dislikes is lost.

It is for that reason that we of the industry reiterate on every occasion that we want our students given a good foundation and that specialization is a cramping from which the student will suffer until we jog him loose. We have stated clearly enough on other occasions what a good foundation should include, but for the sake of completeness repeat it here, at least as far as the chemistry goes—a good course in inorganic, one in organic, another in physical, enough analytical to know the meaning of precision and accuracy in the handling of quantitative methods. In addition, it is valuable to know where to get information about special problems; where to find bibliographies of subjects in which you are interested; what kind of specific trade journals are available; to know which are the best libraries in the country and that they will send you photostats of any articles in which you may be interested at a very nominal cost. The apparatus of chemistry is largely designed to measure physical constants and this apparatus is so fundamental that all courses should include an opportunity for the student to come into contact with the apparatus sufficiently to identify it, not, mind you, taking the time to use each piece. All this can be included in the minimum number of courses required in a major subject for graduation. The rest of the work should be basic and not special, it should have for its purpose rounding out the individual, not as a chemist but as an educated man.

With such a good foundation, not knowing, because it is impossible to know, whether his job will be in an oil refinery, a metallurgical plant, a textile mill, a dye plant or a creamery, a young man is ready to get that

special information necessary to make a success of his job. That is where the industry steps in, and the educational organization that attempts to forecast what the boy is going to be and, just in case of need, puts in a lot of special courses of a technical nature, is bound to get him into trouble and cause him to waste a great deal of time. Why take milk analysis rather than read enough about it to know how it is carried out roughly, if when you come to it you find that your life is to be spent in a tannery; why bother about leather chemistry as a specialty if after getting interested you find yourself doomed to work in a creamery?

Now, taking this outline, it is apparent that the good university or college presents a very good general course and that exception can be taken only to minor differences in the mode of presentation or to the emphasis on the various aspects of the science.

Let us then go over to the question of continuation education. The one side the industrialist alone knows in its real detail and it is that side which the academician, because of lack of personal contact, is least well able to judge. First of all, will it benefit the man or the community, the country or the race, if we urge the industrial chemist as a regular procedure to seek extra education by some intensive method and if we carry our effort so far that we make that, public opinion which counts, cast a stigma upon the industrial chemist if he does not? Are chemists, when compared with other industrial and teaching groups, in any way inferior as citizens or workers? Is it not a fact that their experience in industry gives them more than they can get in any other way? Would an extra effort to keep up in the science of chemistry prove truly beneficial as distinct from pleasurable? Would not the extra effort, coming at a time when the burdens of life are much heavier than during the school period, use too much energy for the benefit gained? Are we not, perhaps, over-emphasizing chemistry and does our industrial chemist not need a broader education in other fields far more than in this science in order to make him more capable of meeting people, of appreciating the interests of others; that is, of developing a personality such as is characteristic of the men we point to as the greatest successes in the industrial chemical field?

The industrialist is the first to be willing to admit his inability to keep up to the minute in his science. However, he asks, without any malice, whether there is any teacher who has ever kept up with the applications of his science, applications of enormous importance and extremely fascinating as they are to any thinking man. He is even willing to go on record as doubting whether the pure scientist finds it possible to keep up with the scientific aspects of his subject.

If the instructor teaching inorganic chemistry is justified in being an inorganic chemist only, in spite of the call of the community to him for his participation as a citizen, if the physical chemist does not feel it neces-

sary to keep up to date in the intricacies of therapeutics, if the organic chemist is satisfied to live in a world of graphic formulas and to consider the making of a new compound an achievement, is not the industrial chemist justified in keeping in touch only with the chemistry of his particular industry, be it rubber, the cracking of oils, catalytic hydrogenation, or the like? We are justified in asking this because we must consider these two groups comparable just as we would compare the head of the department with the manager of a small plant. We can ask which has the narrower field of vision; which of the two is the more and which the less educated, the academician or the industrialist. Is it not true that the industry actually gives a man just as great an opportunity to be a specialist in his field as any university man has to specialize in the study of atomic hydrogen or the meaning of higher spectra? It is true, as witness the fact that some of those men ranking highest as pure scientific specialists are an outgrowth of the industry; a fact which it is obviously quite proper to point out here where the names of many of these men are on the program.

Having said this much let it be said also that very probably a great many industrial chemists do wish to keep more broadly in touch with the science they practice. Let us emphasize that this ambition is a very worthy one and that some step to satisfy it ought most certainly to be taken Educational methods are many and they can be molded to meet the requirements of special cases if we will but recognize the needs of the case and not try to make our educational scheme absorb men who are not suited by the method. We may take it for granted that, if asked, every man who is an industrial chemist would state his desire to keep up to date in all the branches of his science, not minutely but broadly, and yet if you will but consider those whom we call great chemists you will question whether they are great because they are up to date or ever have been. Some very few, yes, but the great majority, no. Actually, those who are the most successful industrial chemists are specialists in managing the man power of chemistry, that is, they are masters in utilizing the special knowledge, coming from many individuals, which must be blended before any great advance in the industry is made. Also, as chemical engineers they understand the coördination between chemistry and engineering which is necessary before laboratory facts can become plant methods. In short, these men are scientific executives with an excellent knowledge of business. They are great chemists because of their own breadth rather than because of their own mastery of the minutiæ of the science.

How can we bring men the chance of getting what they wish with the least loss of time or effort, at the lowest cost, and with the minimum disruption of a man's business and family life? As we see it there are four ways of attempting to achieve this result.

(1) The industrial organization itself might look after the matter, but this could work only in the case of organizations having a large enough group of chemists, and that is restricting it to relatively few. Then there is the disadvantage in any group chosen from one industry, that the meetings are apt to degenerate into a discussion of the particular problems of that industry, which is diametrically opposite to the idea upon which we are working. Moreover, only the large industrial organizations can invite great men from all over the country, even from other nations, to participate, thus securing that personal contact with those men whose very names are stimulating to the chemist. And finally a method such as this is apt to involve paternalism and not depend entirely on the men's own initiative.

(2) A chemical institute such as this, which is having its initiation this summer at State College, has great advantages. It brings together notable men in the science and kindred spirits and it brings them together in the proper atmosphere of study, the campus. Yet the scheme presents a great many very obvious difficulties from the industrialist's point of view and we wish to mention, in a purely constructive way, some which occur to us:

(*a*) No man, after a number of years out of school can step into the class-room and absorb information as fast as it is offered him without a systematic review leading up to the class-room treatment of a subject. The formal courses presented here at this Institute do not offer the industrial chemist material suitable for his purpose. They are, apparently, regular courses such as are given at present in any department of chemistry. That seems inevitable and yet if those courses are intended for the industrialist they are bound to be a failure. It is possible that a man three years distant from his graduation might be persuaded to sit in a class-room. It is impossible to get anyone twenty years out to do anything of the kind. That means that those men who in a certain measure are most interested, the senior men of the industry, will not be attracted to any institute offering formal courses. They know that the average lecture which they hear gives them a lot of material which to them is commonplace and then presents them with facts with which they are entirely unfamiliar as though they were commonplaces. In consequence, they are bored by what they understand and depressed by what they do not understand. If you say that the courses scheduled are not intended for the industrial chemist but that he is to get his inspiration from contact with great men during his hours of relaxation and during the special discussions and lectures, then the advantage is perhaps too vague to appeal to the industrialist. Time to him is so precious that he wants to know just what he is going to get from it. If he knew definitely that he were going to associate with a great chemist at the table, informally, play golf with

him, and listen to him discourse in the evening, he probably would come, but when he knows that he is going to be merely one in a group somewhere in the neighborhood of the great man and may or may not have the pleasure of talking to him, and may never hear him discourse on his subject in terms that are comprehensible to him, then he wavers and stays away. Again, let us be fair and let us be candid. The Institute is the practical expression of the feeling that advantage is to be gained by immersing the industrial chemist in an academic atmosphere tempered by the active coöperation of the leaders in industrial chemistry. Its origin is to be traced to the belief, common both in the industry and within the institution of learning, that the man who becomes an industrial chemist at once begins to lose his knowledge of chemistry, slides gently but steadily to the level of the "routine" man who acts more by rule of thumb than in the light of applied theory, who is actually increasingly ignorant of his subject. Now is that fair? It is true that the chemist does not have his subject in mind in the same general way necessary to one giving a course in general, organic, or physical chemistry. On the other hand, he has been busy acquiring a facility in a special field; a much more intimate, a much more special knowledge than that of his academic brother. Moreover, he has become aware of the economics of chemistry, of the meaning of quantitative processes as governing profit and loss. He has become an employer, an executive who exacts obedience from full grown, independent men by working with them and retaining their respect, a task which is actually just as difficult as the handling of large classes of boys and girls drilled in obedience to the method about them. This being true, is it fair to ask the industrial chemist to accept a position of inferiority and to sit at the feet of the academic specialist who talks down to him with a certain amount of pride? That relation is one which the industrial chemist finds too uncomfortable to be pleasing. Frankly, it bores him because at heart he knows himself to be just as much a specialist in chemistry as the great academician and he knows that were he to set the examination on a practical scale the theoretical man, if you want to call him that for lack of a better term, would fail dismally.

(*b*) There is another difficulty in this scheme. It is intended that the industrial man should devote some of his vacation to attending the Institute, *i. e.*, to the acquisition of fresh knowledge. However, conditions in the plant call for such intensity, are accompanied by so great a stress, that the chemist is going to suffer physically if he does not relax completely from anything chemical during the very short two weeks measuring the standard vacation time. To one who has been of the academic family for so many years the popular notion that teaching is a loafer's job is absurd; but it is equally certain that the plant chemist has a harrowing life. His responsibility is much more tangible than that of the teacher.

He must produce on schedule and that may mean working Sundays and being on call nights for weeks. He must produce economically, which requires that he have his men trained to avoid mistakes and that he see that they do so. If things are going well the chances are that he will be called upon to produce more than his equipment was ever intended to produce. All this tends to wear out nerves and the cure is not in the class-room.

(*c*) It is necessary in any plan such as that of continuation education to consider the attitude of the employer. If a man is to ask for time over and above his vacation and the vacation is, you will remember, to be sacred and not employed at any institute, then he must assure his employer that he is going for work and not for any kind of recreation. He certainly will not receive a favorable hearing if he asks time to go to what turns out to be a second or third glorified American Chemical Society meeting each year. The combination of recreational facilities and work is the very thing that will attract those who are willing to listen but not so willing to work. The devotee of chemistry needs no sugar on his pill. Now the employer will find it a very difficult matter to give two to six weeks a year every few years to all the men in his employ and it is very doubtful whether he would really find it a profitable plan to encourage the men to seek such continuation work.

(*d*) The industrial man must consider time as a powerful factor in life, perhaps to an extent which seems far-fetched to the academician but the industry takes the attitude that the high-priced man should be safeguarded from using his time to do what can be done by anybody less high priced and, therefore, all the drudgery contained in class work has ceased to be anything but real drudgery and pure waste of time to the industrial man. He is accustomed to having a stenographer to take dictation. He is accustomed to having an errand boy to save his steps, a man to set up apparatus; he is accustomed to having a dish washer; usually he communicates with his fellows over special telephone wires; file room and library are at his service without his taking his own time to look for information; all this with a view to saving a few moments. If he comes back to a class-room where he is expected to do laboratory work and all this routine drudgery is left to him, he will come once but he will never come again.

So we come to the next suggestion:

(3) The ideal plan would be to have an organization, call it an institute, if you wish, offering straight work without any emphasis on the side of pleasure and with no credit, a seminar institute where a group of men could go practically for private instruction, no more than three or four of them to be handled by one adviser. Such an adviser would have to be a broad, first-class teacher, alive to the needs of the industry and he would, by

personal consultation, take the men over the subjects in which they are interested, find out what they know, learn their weaknesses and help them to fill in the gaps in their knowledge. This would mean more work, of course; it would mean very hard work, but the ambitious chemist, could rise to the occasion and would be glad to do so. Obviously, such a plan could not be attempted for any fee of $20 for four weeks. The chemist would be prepared to pay anywhere from $100 to $200 for this intensive course and on that basis it might be possible to make it worth the while of the teacher. Inasmuch as the course would be a personal contact the whole of the fees might go to the consultant. Such a scheme would require a central bureau, a function perhaps of the Institute of Chemical Education, to keep in touch with the men and their needs on the one side and with possible teachers on the other, a bureau that would bring together those men asking for the same type of instruction and arrange a time for their meeting at some university where they could benefit from the help of an authority. It would not be possible to fix any time of the year for such work. It would have to be so flexible a method that when some men could get off they could receive attention. Again it is necessary to emphasize the fact that the industry cannot let men go on any schedule. It is the work that they are doing which must be thought of first. This plan is visionary but it is very alluring.

(4) The simplest way of effecting the purpose of continuation education is that of revamping the characteristics of the meetings of the American Chemical Society. At present, except for a number of lectures, which are usually more popular than necessary to meet the needs of the chemist, the emphasis is all on divisional meetings, that is, we try to push the chemist back to the special group in which he labors all the days of his life. In addition, if we will be but candid, we allow of the crowding of the program with a mass of papers of interest only to their authors, possibly in some cases to a few specialists. At the Richmond meeting three papers in succession were read before one division, no one of which had any business whatsoever on the program of a scientific society and none of which conveyed any information to any of those present. The audience sat through the ordeal as a courtesy to the men speaking and that was all. Let us cut down on this sort of thing very harshly and substitute longer and more frequent presentation of subjects of general interest by recognized authorities in terms of chemistry, not for the layman, but for the chemist, preferably with a certain amount of debate between those presenting different aspects of the subject, so that those on the floor could take part. These broad meetings, would be the very antithesis of the symposia which are now developing. If such a turn could be given to the American Chemical Society meetings it would be possible to get a much more generous response from the companies giving their men

time to attend the meetings and the industrialist would find what he needs to get him out of his rut much more readily than by any other system available at present.

Keeping Qualities of Apples Forecasted. Chemists have discovered a method of forecasting the storage life of apples.

Working for the Food Investigation Board of London, Dr. D. Haynes and Miss H. K. Archbold have found that the keeping quality of apples varies with the chemical composition. If the apples contain a good deal of nitrogen, protein that is, and not much sugar, they will only keep for a short time. If they do not contain much protein and plenty of sugar, they will show excellent keeping qualities.

Further evidence that this is the true explanation has been obtained by Dr. Franklin Kidd and Dr. Cyril West, working at Low Temperature Station, Cambridge. They have studied the respiration of apples as a measure of their vital activity. During the "breathing" process the apple oxidizes its store of sugar, and when the store is exhausted, death soon follows. Dr. Kidd and Dr. West found that the apples that keep well, those with low protein and high sugar content, respire more slowly than those with poor keeping qualities.—*Science Service*

Beryllium, New Light Metal, Promises to Rival Aluminum. Airship frames and light-weight pistons may soon be made from beryllium or its alloys, and this hitherto unknown metal may soon achieve the household familiarity that aluminum has won during the last two or three decades.

Beryllium is a metal about a third lighter than aluminum, but is very much harder, scratching glass easily like hard steel. According to H. S. Cooper, industrial chemist of Cleveland, Ohio, who has been conducting extensive experiments, it is one of the most remarkable of all metals in its elasticity. It is over four times as elastic as aluminum, and 25 per cent more elastic than steel. And while aluminum corrodes easily on contact with salt water, beryllium shows very high resistance to this as well as to other metal-destroying liquids and fumes. It is light gray in color, and takes a polish like that of high-grade steel.

It is chemically related to aluminum and easily forms alloys with it. One of these, consisting of 70 per cent beryllium and 30 per cent aluminum, is one-fifth lighter than aluminum, far more resistant to corrosion, and in tensile strength far exceeds duralumin.

One quality, which Dr. Cooper points out, may render beryllium especially valuable to the automobile industry. It expands under the influence of heat at about the same rate as cast iron. Thus when used for light pistons inside the iron cylinders of automobile engines it will present far less engineering difficulty than do the present types of light pistons which expand at a rate different from that of iron.

Beryllium ores are found abundantly both in this country and abroad. At present they are hauled out of feldspar mines in New England by hundreds of tons, but are dumped away as waste. The commonest type of ore is known as beryl, polished crystals of which are sometimes worn as semi-precious stones.

Although so new industrially that it cannot properly be said to have been born yet, scientifically beryllium is an old story. It has been known to chemists for 130 years; Vauquelin, a Frenchman, first indicated its existence in 1797. But until recently it has remained merely a museum curiosity and a laboratory material, because it is so refractory that the cost of getting it in anything like a pure state has been prohibitive. But now that the cost of manufacture promises to be materially reduced by a new electrolytic process, it is probable that it will appear on the market in quantity within a few years.—*Science Service*

ACCOMPLISHING MUCH BY DOING NOTHING

GUY BARTLETT, GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

Robert Burton, an English writer and philosopher of the early 17th century, expressed his idea about nobility in the quotation. "For idleness is an appendix of nobility." Goldoni, an Italian writer of the following century, said, "Noble blood is an accident of fortune; noble actions characterize the great."

There has been enacted in the realm of chemistry, during the past half century, a laboratory drama which closely parallels these two quotations. It has to do with the noble gases—helium, neon, krypton, xenon, and argon—and, particularly, with argon.

During the last decade of the 19th century the five noble gases were discovered on the earth, although the presence of one of them, helium, in the atmosphere of the sun had been recognized a quarter of a century earlier. Argon, the commonest of these rare gases, was the first to yield to the investigations of scientists, being obtained by Rayleigh and Ramsay in 1894–95. Its name is an appropriate one, being derived from the Greek word *argos*, or inactive. It is present in the atmosphere to a concentration of about 94/100ths of one per cent.

The five gases are entitled to nobility because of their rarity, if for no other reason. Xenon, for instance, makes up only one in 170,000,000 parts of the atmosphere. But there is still another reason why they are noble gases—they refuse to associate with other elements, even those in their own noble class, in the formation of chemical compounds.

Robert Burton's expression, "For idleness is an appendix of nobility," certainly could be applied to these gases for many years after they had been discovered, for no chemist was able to make use of them. In view of this fact the name of argon, the lazy gas, was especially appropriate.

Most elements are of interest to the chemist principally because of their activity, but in the case of the five noble gases it is the property of inactivity which has made them of so much importance today. One of them, argon, is accomplishing much by doing nothing; in fact, it is saving the people of the United States nearly a third of a billion dollars every year simply because it is not chemically active. Helium and neon also have assumed positions of commercial importance, and so would krypton and xenon except for their rarity.

Thus, according to the definition of Goldoni, these gases now are truly noble. "Noble blood is an accident of fortune; noble actions characterize the great" certainly can be applied to the history of argon. It was assigned to noble classification upon its discovery, and it was as idle as its name indicates. Hence Burton was right. But argon, by reason of

that idleness, has become most useful, so that Goldoni's definition now fits its case admirably.

Photo by Edison Lamp Works

THE LARGEST AND SMALLEST INCANDESCENT LAMPS

The smallest is a "grain-of-wheat" lamp used by doctors; the largest is a gas-filled one used in motion-picture experiments.

Cutting Down the Lighting Bill of the Nation

It is in the field of electric lighting that argon is saving America nearly a third of a billion dollars annually. Well over a half billion incandescent lamps were sold in this country last year. Three-fifths of these, or 312½

millions, were "large" lamps, and the other 202 millions were "miniature" ones. Of the "large" lamps, about 18½ millions had carbon filaments, and the other 294 millions had tungsten filaments. The vacuum-type tungsten lamp is about four times as efficient as the carbon lamp in producing light.

Tungsten lamps are of two general kinds, vacuum and gas-filled. The larger ones are usually gas-filled, and the smaller ones vacuum. The 1926 production included 173,000,000 vacuum lamps with an average of 33¼ watts each, and 121,000,000 gas-filled ones with an average of 96 watts each. The average-size gas-filled lamp is 55 per cent more efficient than the vacuum lamp as a light producer, so that the gas-filled lamps of last year used nearly three times as much current and produced 4½ times as much light as did the vacuum lamps.

The gas-filled lamps sold in 1926 totaled 11,600,000,000 watts. To have produced the same amount of light with vacuum lamps would have required an additional 6,380,000,000 watts. Taking the average life of an incandescent lamp as 1000 hours and the cost of electricity as only five cents a kilowatt-hour, use of vacuum rather than gas-filled lamps of the larger sizes would have cost the American people approximately an additional $320,000,000 for their lighting bills last year.

Both nitrogen and argon are used in the gas-filled lamps. In the lamps of average household size the gas is practically all argon; in the large, high-voltage lamps there is a mixture of half nitrogen and half argon. A gas-filled lamp of less than about 0.4 ampere is, as yet, less efficient than the vacuum lamp, so that smaller tungsten lamps are still of the vacuum type.

A Remedy Is Sought for Lamp Troubles, and Is Found

Fifteen years ago it seemed that a high degree of vacuum was even more important in tungsten lamps than in carbon lamps. Bulbs blackened with use, and the candle power and efficiency decreased considerably. Slight traces of gases in the bulb were blamed for this blackening, and efforts were constantly being made to improve the vacuum.

Dr. Irving Langmuir, in the Research Laboratory of the General Electric Company, undertook a study of the traces of gases within the bulbs. He devised special apparatus for both qualitative and quantitative determinations of the different gases, the total volume of which is exceedingly small. His analyses were successful, and he found that the residual gases included water vapor, oil (hydrocarbon) vapor, carbon monoxide, carbon dioxide, and hydrogen. He not only was able to analyze the tiny amount of gas quantitatively, but was able to determine that the gases came from the filament, the anchors, the lead-in wires, and the glass. He even found out where each different gas came from, and

what proportions of the gas were released by the different parts of the lamp.

Having accurately determined what gases were in the evacuated bulbs, Dr. Langmuir then proceeded to determine the effect of each on the life and efficiency of the lamp. This was done by introducing small quantities of the individual gases, up to about a tenth of a millimeter pressure, in the lamps.

He found that molecular hydrogen was dissociated, that the atoms were very active chemically, but that dry hydrogen had no tendency to cause blackening.

Oxygen combined with the filament to form an oxide which coated the bulb with a deposit, but it did not cause blackening.

Nitrogen did not attack the filament, but it did combine with tungsten evaporated from the filament. This deposit was brown, rather than black, however.

Carbon monoxide resembled nitrogen in its behavior, and so did carbon dioxide after being reduced to carbon monoxide. None of these four gases, then, was responsible for the blackening.

Water vapor, even in extremely small amounts, was found to produce blackening, even though neither hydrogen nor oxygen by itself did so. In other words, water was the poison sought. The water was broken down into its constituent atoms, hydrogen and oxygen. The oxygen attacked the filament and caused deposits of oxide on the bulb. The chemically active atomic hydrogen then attacked the deposit, combining with the oxygen to reform water vapor, reducing the deposit to black, metallic tungsten. Constant repetition of this cycle meant that even a tiny amount of water vapor within the bulb would quickly cause serious blackening of the lamp.

Dr. Langmuir's experiments did not stop there, however. He continued his investigations with other vapors such as chlorine, bromine, sulfur, hydrochloric acid, methane, etc., but in no case did he find blackening of the bulb. He concluded that water vapor must be responsible if the blackening was caused by imperfect vacuum, and thereupon devised an evacuating system whereby the vacuum of the lamps was improved from a millionth to less than a billionth of atmospheric pressure.[1]

Even with the greatly improved vacuum and all of the precautions to exclude the slightest trace of water vapor, bulbs continued to blacken slowly. Dr. Langmuir, therefore, concluded there was a slow blackening resulting from true evaporation of the filament. Results of tests conducted along these lines agreed with his theoretical figures.

Air pressure hinders the evaporation, or boiling, of water—boiling occurs

[1] The operation of the Langmuir mercury vapor pump was described in "High Vacua and High Frequency," THIS JOURNAL, 4, 604–9 (May, 1927).

at a lower temperature on a mountain top than in a valley where the pressure of the air is greater. With this law of physics in mind, Dr. Langmuir proceeded with experiments to check the evaporation of lamp filaments by introducing a gas pressure in the bulb.

Hydrogen was the first gas used. At atmospheric pressure, the loss of heat due to the conductivity of the gas was so great that 17 times as much current was required to produce the same amount of light as in a vacuum lamp, but the lamp did not blacken. He found later that the heat loss with hydrogen was abnormally high because the hydrogen molecules broke down into atoms, thereby absorbing added electrical energy.

Mercury vapor was then tried. The heat loss was much less than when hydrogen was used, and the rate of evaporation of the filament was greatly retarded.

Nitrogen was found to decrease the rate of evaporation of the tungsten filament, but the experiments showed that, if the gas-filled lamp was to have a higher efficiency than the vacuum lamp, a modified filament was needed.

Dr. Langmuir, while studying abroad in 1903–05, had experimented with heated platinum wires in dissociating steam and other vapors. These experiments led to an interest in the laws governing the dissipation of heat from hot wires, which line of experiments he followed after joining the staff of the Research Laboratory. He found that the heat loss varied with the temperature, and with the diameter of the wire according to a complicated formula. The experiments showed, however, that in the case of small wires, say a thousandth of an inch in diameter, the heat loss did not differ much from those of larger diameter. Dr. Langmuir believed this to be due to a layer of hot gas adhering to the filament. The thickness of this gas layer is independent of the diameter of the wire, being about one-sixth of an inch thick. Halving the diameter of the wire does not halve the thickness of the gas film, and the cooling surface of a thin filament is, therefore, relatively greater than that of a thick filament. More heat is lost with thin filaments than with large wires. The next conclusion was that gas-filled lamps should have filaments of larger diameter so as to reduce heat losses.

Dr. Langmuir thereupon made two sets of lamps with thick filaments, one set being nitrogen-filled and the other vacuum. The experiment failed, as far as the nitrogen-filled lamps were concerned. Black deposits had been formed on the upper part of the gas-filled bulbs, whereas a nitrogen-deposit would have been brown. Believing that water vapor was, therefore, responsible for the failure of the first experiment, Dr. Langmuir repeated the work with added precautions to exclude moisture. The new experiments were a victory for the nitrogen-filled lamp.

Dr. Langmuir decided that the effect of a thick filament, as far as

the surrounding gas film was concerned, could be obtained with a properly coiled small filament. By winding the fine wire on a mandrel, or spindle, of relatively large diameter and by having the turns of the wire close together, the gas film would be the same as though the filament were of the external diameter of the coil. Having determined the best mandrel sizes and spacings between coils he was then able to make a nitrogen-filled lamp, consuming 1000 watts on 110-volt circuits, which was twice as efficient as vacuum lamps for the same life.

High-vacuum pumps are not needed for exhausting gas-filled lamps, but the removal of moisture is a serious problem. The water vapor is removed in regular factory practice by washings with dry gas. Dry air is used for the first washings and dry nitrogen for the later ones. Thus all the air and other vapors are removed. When the lamps are sealed off they contain a sufficient amount of argon, with about 15 per cent of nitrogen, so that the pressure equals atmospheric pressure when the lamp is burning.

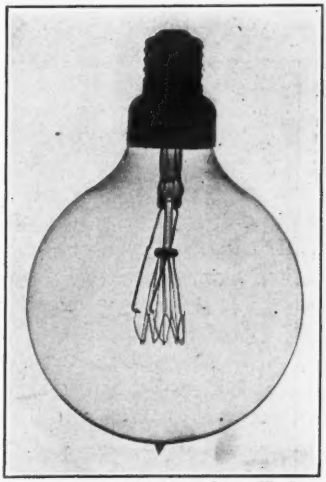


Photo by Edison Lamp Works

THE FIRST COMMERCIAL MAZDA C LAMP (1913)

In 1913 the 1000- and 750-watt gas-filled lamps were introduced commercially. They were made with round bulbs and tubular necks, with a mica disk within the neck to keep the hot gas from circulating in the neck and heating the socket. As time went on the shape was changed to a straight-sided bulb, and then to pear-shaped. Similarly, it became possible to make efficient gas-filled lamps of smaller sizes, until today the gas-filled lamp is standard in all of the larger sizes.

A mixture of argon and nitrogen is used in gas-filled lamps because its heat conductivity is lower than that of pure nitrogen. Dr. Langmuir found that argon by itself is a conductor of electricity and causes arcing from one end of the filament to the other, but he also found that the addition of a small amount of nitrogen remedied this trouble.

A Rare Gas Becomes More Common

Dr. Langmuir's invention of the gas-filled lamp was only one step in the commercial introduction of the product. At the time of his experiments argon was a rare gas, and it was necessary to develop a process

whereby large quantities of the gas—present in the atmosphere to the extent of less than one per cent—could be obtained in pure form conveniently and cheaply. Some time elapsed, therefore, between Dr. Langmuir's experimental lamp and the lamp of commerce, the time being devoted to the development of a method for obtaining argon in quantities. The first commercial lamps contained only nitrogen. Only after a supply of argon could be obtained two years later was it possible to use argon, with its lower heat conductivity.

The argon used by Dr. Langmuir in his experiments cost ten dollars per cubic foot, and was imported from Europe. The argon of today costs only a few cents per cubic foot. Between the two extremes there is a story of an American, J. G. Wild, escaping from Europe just before the outbreak of the World War, and bringing to this country a sufficient quantity of the gas so that the developmental laboratory of the National Lamp Works of the General Electric Company at Nela Park, Cleveland, could conduct experiments in the production and purification of the gas.

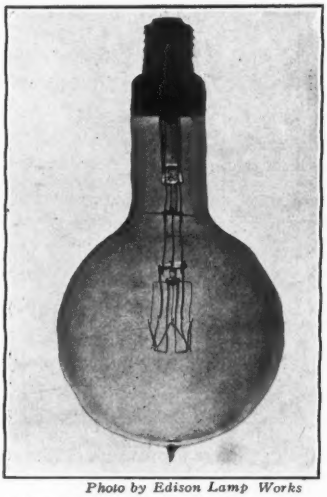


Photo by Edison Lamp Works

THE MAZDA C LAMP OF JANUARY, 1914

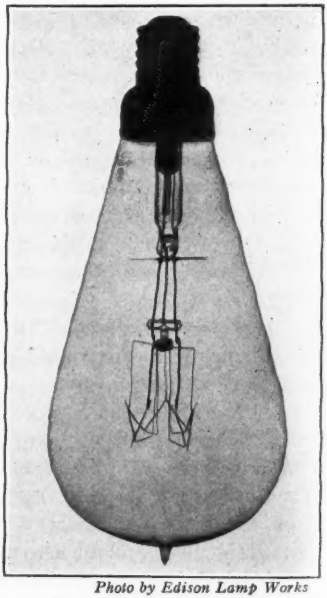


Photo by Edison Lamp Works

THE MAZDA C LAMP OF JULY, 1914

Before the end of 1914 the laboratory was able to supply the lamp factory at Cleveland with some of the gas, and shipments were started to other plants in February of 1915.

At first the laboratory obtained crude argon from an air products com-

pany in this country, and purified it before shipment to the different factories. But as the demand for the gas increased, it was decided that an argon plant should be built in Cleveland for both production and purification of the gas. This plant was constructed in 1919.

In this plant the dust and carbon dioxide are first removed from the air in scrubbing tanks, water removing the dust and caustic removing the carbon dioxide. The air is then sent through a machine which compresses it under a pressure of 4000 pounds per square inch, greatly reducing its volume. Its temperature also

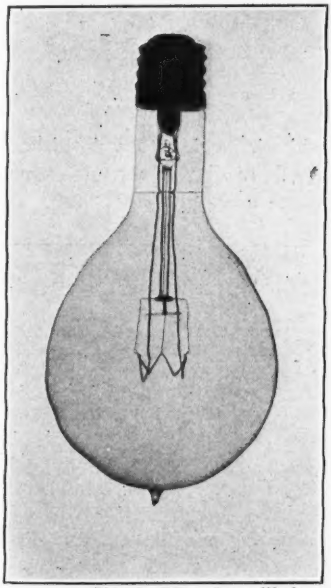


Photo by Edison Lamp Works

THE MAZDA C LAMP OF 1915

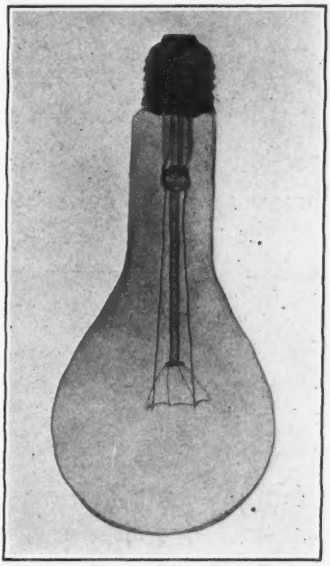


Photo by Edison Lamp Works

THE PRESENT-DAY MAZDA C LAMP

This 150-watt lamp is designed for 115-volt circuits. Higher wattage lamps are similar in appearance.

must be reduced before it can be liquefied, so the air is sent to interchangers where the temperature is decreased nearly to the point where liquefaction occurs. This drop in temperature is produced by surrounding the interchanger tanks with frigid gases from the fractionating column.

The air, under high pressure and at a low temperature, is conducted from the interchanger to the fractionating column or still through an expansion valve. In passing through the valve the pressure suddenly drops from 4000 to six pounds per square inch, and this sudden expansion causes the air to drop in temperature to such an extent that it becomes liquefied.

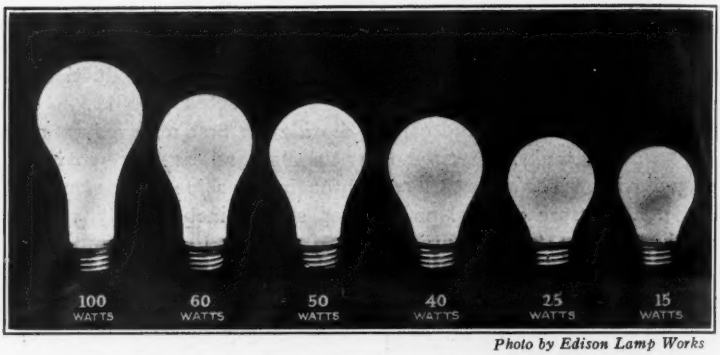


Photo by Edison Lamp Works

THE INSIDE-FROSTED, GAS-FILLED LAMPS OF TODAY

In the fractionating column the liquid air begins to volatilize. Nitrogen, the most volatile of the gases, immediately starts to become a gas again. The oxygen and argon trickle down the sides of the still,

Photo by Edison Lamp Works

FILLING ELECTRIC LAMPS WITH ARGON

The lamps are shown with their exhaust tubes stuck in holders on the edge of the turntable at the right of the picture. This table revolves, and pipes connect through a valve system to each lamp so that each lamp is first exhausted, then "washed" with dry air to absorb water vapor, re-exhausted and connected to a supply of nitrogen and argon which is admitted at slightly below atmospheric pressure.

but the argon starts to boil off before it reaches the bottom of the column. The still is so constructed that the gaseous argon is separated from the nitrogen which has already become a gas and escaped, and from the oxygen which reaches the bottom of the still before it boils off.

The argon is piped from the fractionating column to tanks as crude argon, ready for purification before being used in lamps. The frigid

Photo by Edison Lamp Works

THE UNIT LAMP-MAKING MACHINE

The parts are assembled by the operators at the right, the exhausting and gas-filling operations are conducted by the third operator, and the base is attached by the operator at the left.

nitrogen and oxygen gases are sent back to the interchanger which they encircle in pipes to reduce the temperature of the incoming air.

The impurities are removed from the crude argon by means of a chemical treatment. The gas is then compressed into tanks again, ready for shipment to lamp factories throughout the world.

The research scientist has put laziness to work.

Chemistry is the imitator and rival of nature. Its field is almost as wide as that of nature itself; its relation to physics is as that of poetry to the other forms of literature.—DIDEROT

POLAND—A COUNTRY WITH A CHEMICAL FUTURE

NEIL E. GORDON, UNIVERSITY OF MARYLAND, COLLEGE PARK, MARYLAND

As one of the United States delegates to the International Union of Pure and Applied Chemistry which met at Warsaw last September, the writer had the privilege of learning at first hand something of Poland's chemical resources and of the progress which is being made in their development. The most superficial survey is sufficient to convince an observer that the possibilities before this young nation are great indeed, and the spirit of the Polish people forecasts with a high degree of probability the ultimate realization of those possibilities.

Americans who have paid no especial attention to European geography may be surprised to learn that Poland, with an area of over 150,000 square miles, is now the sixth largest state in Europe. Her thirty million people give her sixth place as to population also. Of this number approximately sixty per cent are engaged in agriculture; the remainder in commerce, industry, and the professions.

As a result of dismemberment, foreign domination, and the vicissitudes of warfare, Poland's industrial development was until recently comparatively rudimentary. Naturally a great deal of her energy during these first few years of freedom has been directed toward the restoration of war damages. The magnitude of the task is more fully appreciated when one considers that of necessity it fell to the lot of an inexperienced administration. Yet those who were acquainted with conditions at the close of the war assure us that the achievements of this restoration period have been nothing short of marvelous.

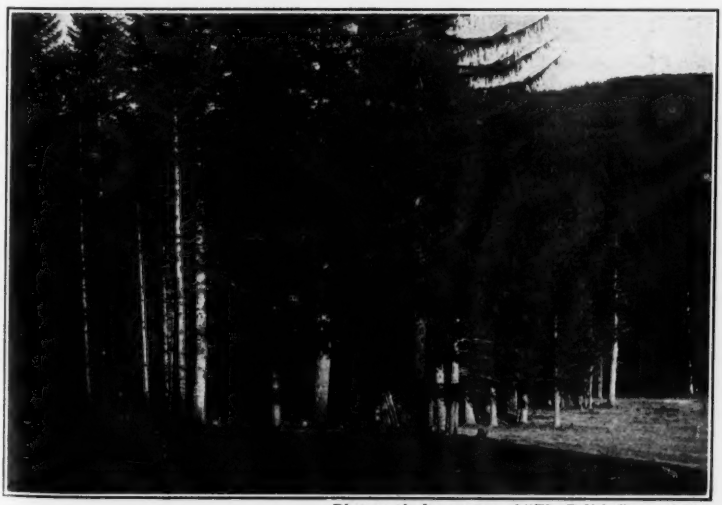
Undoubtedly this work owed its initial momentum to the enthusiasm of a people who had at last won an independence which had been the dream of centuries, but that enthusiasm has been sustained by the results already achieved and by an unfaltering belief in their natural resources. And Poland is not unmindful of the fact that chemistry is destined to play a most important rôle in the development of those resources. This fact is partly evident in the election of a chemist to the presidency of the Republic.[1]

In welcoming the delegates of the International Union he said in part: "The present century is one in which the mantle of power is passing to the chemical industries. In all branches of production mechanical processes give way to chemical processes." When the President of a nation expresses such a point of view and when he is in addition a chemist of no small attainments it requires little exercise of the imagination to anticipate the trend of development in a country as rich in natural chemical resources as Poland.

[1] See Editorial, page 1331.

Agriculture and Forestry

As has already been intimated agriculture is the major industry of Poland. Yet agricultural products constitute the basis for many chem-



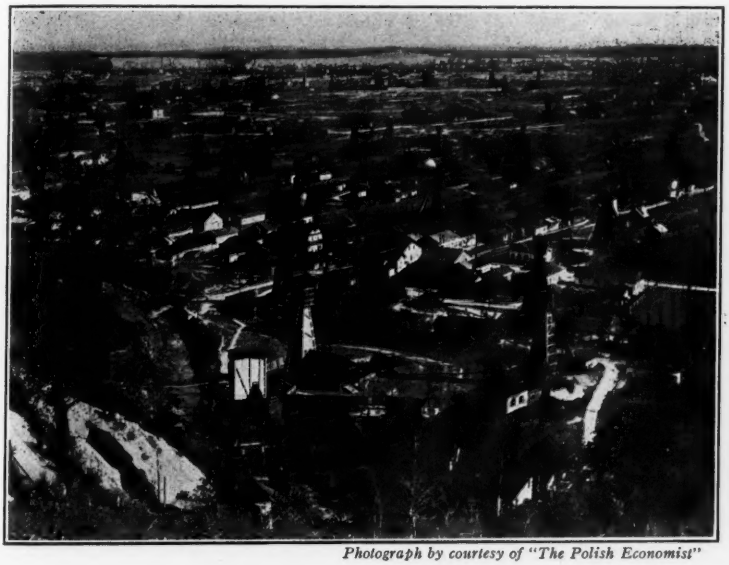
Photographs by courtesy of "The Polish Economist"

Polish Field and Forest

ical industries. For example, the surplus potato crop is utilized in making alcohol, starch, dextrine, potato flakes, and potato flour. All are made in sufficient quantities for export. In 1925–26, about seventeen million

Map by courtesy of "The Polish Economist"

gallons of alcohol were manufactured. The distilleries, fourteen hundred in number, are operated largely by individual farmers or small groups of farmers. Sugar beets are raised in large quantities, so that Poland has sugar for export after supplying her own needs.



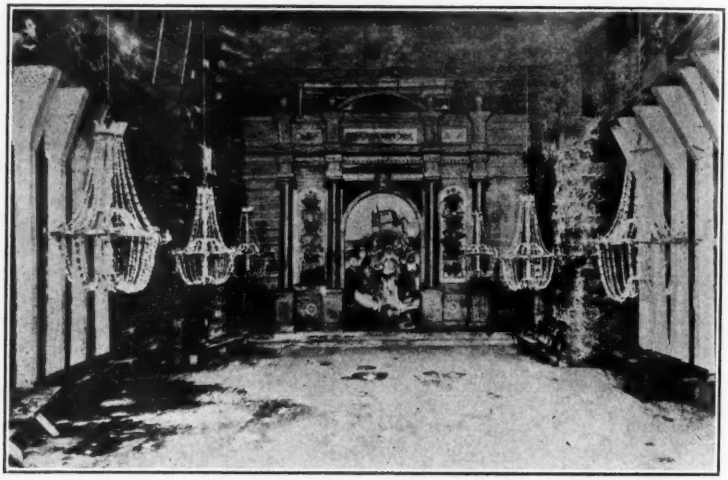
Photograph by courtesy of "The Polish Economist"

PETROLEUM WELLS AT BORYSLAW

The forests also contribute to chemical industry. About twenty-five per cent of the total area of the country is wooded. The predominant species are pine, oak, aspen, alder, birch, and beech. A portion of these, especially pine and beech, is utilized in dry distillations. At Hajnowka is found the largest dry distillation plant in Europe. Since the plants are equipped for the handling of all the products of distillation Poland is able to carry on an export trade in acetic acid, acetone, methyl

Photograph by courtesy of "The Polish Economist"

STATE PETROLEUM REFINERY AT DROHOBYCZ

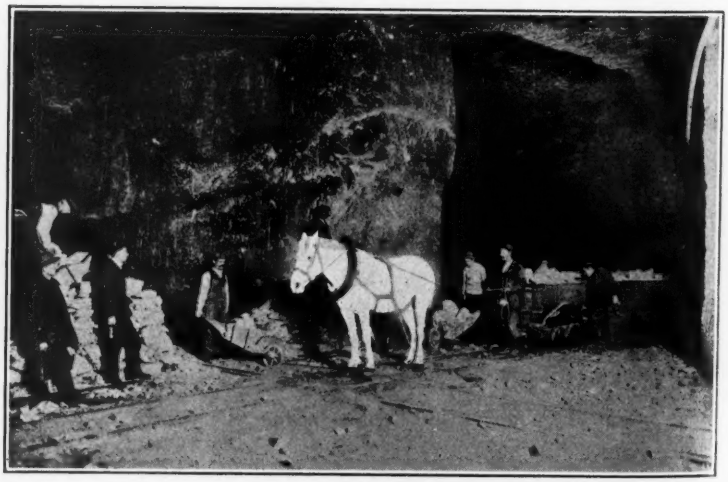


A SUBTERRANEAN CHAMBER IN THE SALT MINES AT WIELICZKA

alcohol, formalin, and other products. Turpentine and rosin are produced to some extent.

Subterranean Wealth

Poland has chemical resources below the ground which far outvalue those above the surface. They include coal, oil, natural gas, rock salt,



SALT MINERS AT WORK

potassium salts, iron, zinc and lead ores, and phosphates. Some of these occur in quantities sufficient not only to supply her own needs but to leave a surplus for export.

Coal

The main coal area is located in the southwest. The coal mining industry operates at present under very favorable conditions: high quality of coal, up-to-date plants, abundant and cheap labor. The total output of coal in 1926 amounted to thirty-six million tons, of which fifteen million were sent to foreign lands (mostly Scandinavia, the Baltic States, and Italy). Poland is the fourth largest coal producer in Europe, being outstripped only by the United Kingdom, Germany, and France. Large quantities of coal are subjected to chemical treatment in coke and gas works. That converted into coal tar alone amounts to 100,000 tons annually. All by-products of the coke plants are utilized, hence Poland is not wanting in benzene, toluene, naphthalene, and other hydrocarbons. The annual benzene production of about 15,000 tons is largely absorbed by the local dye and explosives manufacturers. Polish industrialists are now anticipating new possibilities along the line of artificial motor fuels. The ammonium sulfate obtained from the coke and gas works helps to supply agricultural needs.

The manufacture of dyes in Poland is based chiefly on the coal-tar intermediates obtained locally, yet certain derivatives must be imported. Poland feels that Germany is taking advantage of this fact and thus making the cost of Polish dyes so high that they find difficulty in competing with the products of other countries. Nevertheless the trade with Russia is comparatively active in spite of Russia's unsettled condition.

Petroleum and Natural Gas

The oil fields of Poland are situated at the foot of the Carpathian mountains. In this neighborhood one finds 2400 wells and 29 refineries with an annual output of 710,000 tons of petroleum products such as benzene, kerosene, lubricants, waxes, etc. More than half of these products are exported. Further expansion which, it is claimed, will double present output only awaits the availability of sufficient capital to develop this industry. The production of natural gas is linked with the petroleum industry. In 1926 the output of natural gas was 480,000,000 cubic meters.

Pharmaceutical Chemistry

Closely connected with the development of the dye industry is that of the pharmaceutical industry. Considerable progress has been made since the war. One now finds pharmaceutical laboratories engaged in the manufacture of alkaloids, essential oils, and animal and vegetable extracts, but the development of other fields is at present delayed for lack

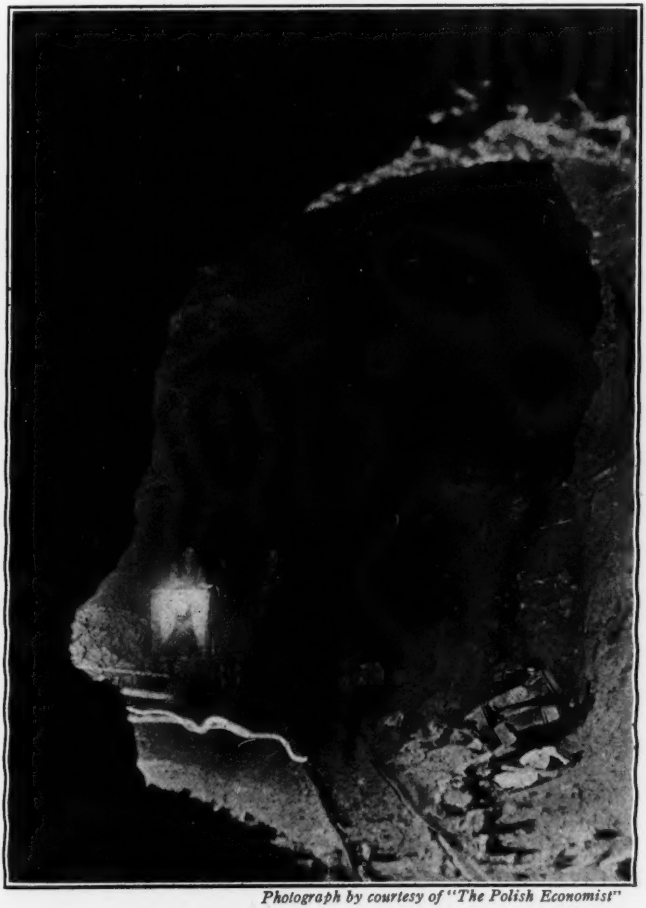
of a supply of pure chemicals. There is a large production of patent medicines.

Rock Salt

Another great industry, the full development of which awaits further capital, is that of rock-salt mining. Large salt deposits occur in the

AN EXAMPLE OF SALT SCULPTURE—THE CHAPEL OF SAINT ANTHONY AT WIELICZKA

south near Cracow and in the west near Inowroclaw. The salt is amazingly pure (about 99 per cent), requiring only pulverizing to fit it for table use. To the visitor, the most interesting features of the mines



Photograph by courtesy of "The Polish Economist"

INTERIOR OF POTASSIUM SALT MINE AT STEBNIK

are the subterranean galleries and halls carved out of the solid salt. Here are found chapels, ball rooms where orchestras play and dances are held, and walls decorated with salt statuary and pictures.

Salt is carried to the surface in cubes weighing as much as eight tons.

The mines are controlled by the State and in 1926 produced 450,000 tons of salt.

Potassium Salts

Possibly the chemical resource which means the most to Poland today is potassium salt, for Poland is primarily an agricultural country and there is great demand for artificial fertilizers. Investigations show that the Polish deposits are the largest in Europe, outside of Germany and Alsace. The potassium salts, like the rock salts, occur principally in two areas: in the eastern part of the Carpathians (formerly Austrian Poland), and in the neighborhood of Voievodship (formerly German Poland). The Carpathian deposits form a belt 5 kilometers in width and 80 kilometers in length. These beds have been investigated in some places to a depth of 2000 meters. The reserve of potassium salt which has so far been discovered in the course of mining operations runs in the neighborhood of one hundred million tons with an estimated K_2O content of fifteen million tons but the total amount is probably larger for potassium salts have been found in the waters of widely separated localities. Extensive investigations are being carried out by a special staff of geologists with a view to discovering new beds suitable for exploitation.

At present the most active development of the potassium deposits is being carried on in the Carpathian foothills region at Kalusz and at Stebnik. The mines are the property of the State but have recently been leased to a private company for a period of forty years during which time the government will receive a two-thirds royalty. Since this arrangement was negotiated much improvement has been wrought. There is an up-to-date concentration plant designed along German lines and capable of supplying the trade with a standard product. The output in 1926 was 207,589 tons.

Ore Possibilities

The largest deposits of iron ores are found in the southwestern region of the country, but it is lamented that this ore is not sufficiently rich in iron to be economically smelted without the addition of foreign ores of higher grade which must be imported from Sweden and Russia.

Most of the foundries are located adjacent to the coal-mining basin in central Poland to the south of Warsaw. Here one finds twenty-four blast furnaces with an output of 330,000 tons of pig iron and 560,000 tons of rolled products (1926). This output is largely consumed by the home and steel industries.

The zinc and lead ores, unlike the iron, are of high grade. Although these do not supply all domestic requirements they form the basis of a well-developed lead and zinc smelting industry. In fact it is claimed to be one of the largest and best equipped in the world and much American

capital has been invested in it. Large quantities of lead and zinc sheets are exported. About 180,000 tons of lead and 120,000 tons of zinc were sent abroad in 1926.

Sulfuric Acid and Superphosphates

Poland has very little pyrites but at present she produces more than enough sulfuric acid for her own needs as a by-product in the working of her zinc blende. Sulfur dioxide, which is obtained from the roasting of the zinc ore, is converted into sulfuric acid. There is one factory which makes sulfuric acid from the sulfur accumulated in iron ore used in the

Photograph by courtesy of "The Polish Economist"

Spinning Room in Viscose Factory at Tomaszow

purification of coal gas. No doubt the increasing use of superphosphates will soon cause the demand for sulfuric acid to exceed the domestic supply. The present annual production of superphosphates is 250,000 tons—a tonnage far too small for the actual needs of the country. Poland has only phosphorites and hence might find it more economical to import her superphosphates than to manufacture them were it not for the fact that such manufacturing gives employment to many needy people.

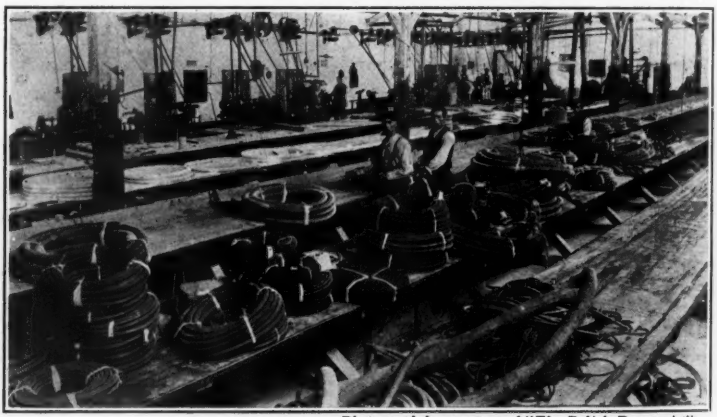
Silk and Textile Industry

Another great chemical industry in Poland is that of silk and textiles. We are told that the production of artificial silk in Poland was begun

before the war. A collodion process was initiated at Tomaszow near Lodz in 1910 and put its first product on the market in 1911. Since the war this factory has also introduced the viscose process.

When it is recalled that Poland has a surplus of alcohol it is not difficult to understand why the collodion process should find favor there. At the same time vigorous research is being carried on with the viscose method.

The textile industry today meets the needs of the home markets and exports not only large quantities of silk but also considerable quantities of yarns and fabrics. The main center of the textile industry is at Lodz—called the "Polish Manchester." Cotton spinning has reached a high



Photograph by courtesy of "The Polish Economist"

CORNER OF A RUBBER FACTORY

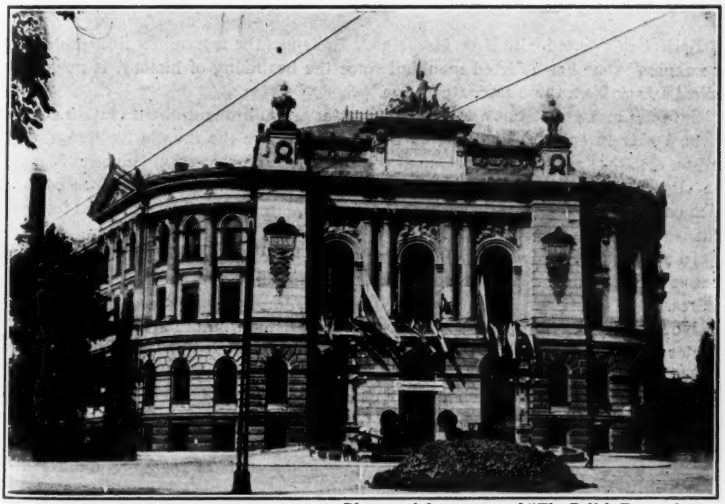
degree of development. Wool follows closely on the heels of cotton and is in turn followed by linen.

Rubber

The rubber industry has also made rapid strides since the war. In fact, before the war there was practically no rubber industry. Even as late as 1923 imported rubber defied competition. This difficulty has not yet been completely overcome but the establishment of import duties has now encouraged the establishment of several comparatively prosperous plants. Some of their best known rubber goods are rubber pressure pipes, rubber sheets, sugar refinery accessories, rubberized textiles, surgical goods, and footwear. There is very little if any rubber exported, but production is rapidly overtaking the demands of the domestic market.

Fixation of Nitrogen

Poland has not been unmindful of the fact that her chemical attention must be centered on the fixation of nitrogen if she is to hold what she considers her rightful place in the world's development. In this connection President Mościcki has won much distinction. Under his leadership the work has developed to a point where the people have reason to feel proud of their achievements. The output of calcium cyanamide in 1926 was 120,000 tons. At Chorzow there is also a factory for the production of concentrated ammonia and ammonium nitrate. Nitric acid is also manufactured. An electrical plant for nitrogen fixation is now



Photograph by courtesy of "The Polish Economist"

The "Politechnika"—the Meeting Place of the International Union

in process of erection. The power will be obtained from the San river near which the plant is being built.

Institute of Chemical Research

Poland has no National Research Council but there is a national organization of great merit somewhat comparable to our own Bureau of Standards. The Institute for Chemical Research, as it is called, is designed to bring about the closest coöperation between chemistry and industry. This is another achievement which may be set down to the credit of the President. The Institute was originally located at Lwow but during the present year it has been brought to Warsaw. Some of the problems being investigated at the present time are: the manufacture of sulfuric

acid from gypsum, the low-temperature distillation of coal, the extraction of aluminum from clays, the improvement of nitrogen fixation processes and the development of new dyes.

The Outlook

Less than ten years ago Poland was in a condition which might easily have led to chaos. Today, thanks to her able leadership, to the splendid spirit of her people and to her excellent resources, she faces bright prospects of ultimately attaining a prominent place among European nations.

Epileptics Treated with New Medicine. Epilepsy, the mysterious, incurable "falling sickness" that has afflicted mankind since the beginning of history, is now under medical attack from three separate angles.

Several years ago it was established that starvation brought about certain changes for the better in epileptics so long as they could endure the drastic treatment. Recently a diet that approximates some of the conditions of starvation has been found to give very successful results with epileptic children. Confined to the prescribed diet which calls for much fat but little sugar, afflicted children have shown marked improvement lasting over a period of years.

In addition, careful and understanding psychological handling has proved to be of great value in avoiding much of the mental and emotional strain that leads up to epileptic seizures.

Now a new weapon in the shape of the drug luminol-sodium is announced by Dr. J. Tyler Fox in a report to the medical journal *Lancet*.

Dr. Fox has tried out the drug in carefully regulated doses on members of the epileptic colony in Surrey of which he is superintendent. Of 167 cases 50, or around 30 per cent, showed benefit that is likely to be permanent. Fifty-one cases, after registering improvement for a period of three months, apparently became tolerant to the drug. The remainder either showed only temporary gains or remained unaltered by the treatment. A very few became worse.

The best results are to be expected from young patients, Dr. Fox pointed out. Some patients have continued to receive the treatment for periods as long as four years, he declared. The drug should be administered with great caution because in some cases the number of fits have increased after the luminol was stopped. In a few cases where the number of fits decreased the behavior of the patients became violent and uncontrolled. The treatment appears to be of benefit in certain types of cases but should not be undertaken where careful supervision and accurate records of each seizure cannot be maintained for each patient.—*Science Service*

Athletes and Miners Use Ultra-Violet Rays. The members of one of the French athletic teams are regularly using ultra-violet ray baths during training, having been convinced of their value in toning up the system.

England, as well as France, is following the example of America and Germany in the use of ultra-violet rays for preventive and curative medical purposes. In the British Parliament a bill is under consideration making it obligatory for light-baths as well as water-baths to be installed in mines, freely available for every miner who has been deprived of sunlight for six hours a day. An enterprising municipality is fitting out ordinary public bath-houses with "artificial sunlight."—*Science Service*

CHEMISTRY AS A LIFE WORK*

JAMES F. NORRIS, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASSACHUSETTS

Why should a young man or young woman take up chemistry as a life work? Is any special bent required for success? What questions should be asked before coming to a decision? These are the points which Dr. Norris touches upon in the present paper.

Let me quote at the outset what the great Paracelsus had to say of the alchemists of his day. He was speaking in the sixteenth century when alchemy, the precursor of chemistry, was at its height. In drawing a comparison between alchemists and physicians, he describes the former in these words:

"For they are not given to idleness, nor go in a proud habit, or plush and velvet garments, often showing their rings upon their fingers, or wearing swords with silver hilts by their sides, or fine and gay gloves upon their hands, but diligently follow their labours, sweating whole days and nights by their furnaces. They do not spend their time abroad for recreation, but take delight in their laboratory. They wear leather garments with a pouch, and an apron wherewith they wipe their hands. They put their fingers amongst coals, into clay and filth, not into gold rings. They are sooty and black like smiths and colliers, and do not pride themselves upon clean and beautiful faces."

Such a picture, however, did not deter the enthusiast in those days from entering upon work so alluring.

Times have changed since Paracelsus spoke. The chemical laboratories of today are palaces compared with the dark cellars in which many fundamental facts of our science were first discovered. But there is still something of truth in the picture. We chemists may be in the white collar class, but our hands are often dirty.

Not many years ago a young man was thinking seriously of undertaking graduate work in the anticipation of devoting his life to chemistry. The professor of physics under whom he had studied presented the beauties of his field of work and advised strongly that the choice be made in favor of the more exact science. "Before you decide," he said, "spend an hour or more in the chemical laboratory and note carefully what the men are doing. Then spend an hour in the laboratory of physics and come to see me again." The suggestion was immediately followed. "Well, what did you see?" The student started to talk about the enthusiastic workers in the chemical laboratory and the interesting problems they were study-

* An address delivered at the dedication of the Hall Laboratory of Chemistry at Wesleyan University, Middletown, Conn., May 14, 1927.

ing. The professor interrupted, "Yes, I know all about that. But tell me. Didn't you find most of the men in the chemical laboratory washing dirty dishes and trying to get something out of mucky tars? And in the laboratory of physics were the men not working with most interesting types of delicate apparatus and making measurements with a very high degree of precision. Which kind of work would you rather do?" The student chose the dish-washing and the tars, because behind these was a realm of inquiry that appealed to his imagination and aroused his enthusiasm to take part in the solution of such vital problems.

Some, however, cannot see behind the disagreeable tars. You can find this lack of vision in Sinclair Lewis' "Arrowsmith." Professor Gottlieb asks Martin Arrowsmith, who wants to take a course in bacteriology, "Have you taken physical chemistry?" "No sir, but I did pretty well in organic." Then comes the broadside: "Organic Chemistry! Puzzle Chemistry! Stink Chemistry! Drug Store Chemistry! Physical Chemistry is power, it is exactness, it is life. But organic chemistry—that is a trade for pot-washers. No, you are too young. Come back in a year."

Evidently Sinclair Lewis does not know that organic chemistry has saved countless lives and is banishing suffering from the world. No professor of bacteriology would utter such a diatribe. A little knowledge is a dangerous thing.

Why should a young man or a young woman take up chemistry as a life work? Is any special bent required for success? What questions should be asked in coming to a decision?

The answers depend on one's point of view in regard to life. To me one word stands out, apart from all the rest—Happiness. Happiness based on a praiseworthy philosophy. It must be free from selfishness and inspired by altruism.

I place first, joy in the work. When the youngster tells you he wants to be a locomotive engineer, or a policeman, his selection is based on the best of common sense. He is fascinated by the job, he likes the kind of work, and thinks he would be happy behind the throttle or in the dressy uniform which means authority.

But as the lad grows up and his horizon broadens, he becomes uncertain. So many new factors enter—many, insignificant, are unduly magnified—and the fundamental desire for happiness in the work is lost.

Real happiness in one's life work, as I see it, depends on many considerations and relationships. Is the work worthwhile? An attractive young man called on me a short time ago to ask my advice as to taking up postgraduate work in chemistry. He had been awarded a bachelor's degree about ten years ago, and had studied in college a little chemistry which had interested him more than any other subject. An opportunity to

enter business immediately led to the work in which he is now employed. He was discontented. "I am making a very good living," he said, "but what does it all amount to? I sell gypsum, and have been doing so for years. I hate gypsum and I hate selling gypsum. I want to be happy in my work. Is it too late to take up chemistry again?" He had made a mistake. It sometimes happens the other way. I know a chemist who should have devoted his life to the violin.

Is the work worthwhile? We can get our answers to this question by studying what the world thinks of the significance of chemistry and its attitude toward the chemist. Are we of the profession proud to say that we are chemists? What justification have we for our pride? What has chemistry done in an advancing civilization?

It has been in recent years only that the public has come to realize the importance of chemistry and science in general in world progress. Formerly there was no means of communication between the man in the street and the worker in the laboratory. And even the average educated man—the product of the college—who had absorbed something of what we call culture, was uninformed as to the nature of science and its methods and the intellectual, social, and economic development of the world as the result of the growth of pure and applied science. Culture meant a knowledge and appreciation of art, history, and philosophy.

It was my good fortune to study, as a college student, an enlightening book on the intellectual development of Europe. I learned to my great joy that other agencies than wars and changing dynasties had been factors in world progress. And science was one of these.

But even today much remains to be done to win the recognition of a philosophical appreciation of science as a part of the mental equipment of a cultured man. In interpreting the world of today the contributions of Lavoisier and Faraday are as worthy of consideration as those of Homer and Michael Angelo.

The great advance in recent years in applied science touches closely the lives of us all, and has caught the attention of the world. Chemistry, alone or in alliance with other sciences, has led in adding to our material advancement. Cement and steel, the products of chemical research, have largely replaced wood and stone as building materials. A great city like New York with its massive tower-like buildings would never have come into being without the products of the chemist's brain. Our clothing owes much to the chemist's touch, and our food is abundant and wholesome as the result of the study of the chemical principles involved in the fertilization of the soil and in the use of animal and vegetable materials in the upkeep and growth of the human body. Calories and vitamins are, today, household words. The chemist protects our health and is learning how to repair the damage in many cases when the machinery

breaks down. Hundreds of thousands have been cured of hookworm disease and other scourges through the application of specific substances discovered and developed by the chemist.

We can trace many things that add so much to our comfort and pleasure in living, to his laboratory. Chemistry fights our battles and helps to disseminate happiness when the victory is won.

Such achievements cannot but inspire the youth who wants to take an active part in the world's work. He can be proud of his profession. Each one can contribute his bit toward the solution of a problem that means much in the common welfare.

To be more specific—just what kind of work does the young chemist undertake when he goes forth to win his way? Concrete examples taken from the experiences of some of my former students will answer the question. One has helped in developing an improved material to be used in making films for moving pictures—a material that eliminates the fire hazard associated with the use of the present type of film. Another is developing dyestuffs fast to light and washing. A third is devising control methods to be used in the manufacture of synthetic ammonia—a substance of the greatest importance in chemical industry. A fourth is improving the properties of lacquers so that it will not cost so much to keep our automobiles bright and fresh in appearance. One is studying the metabolism of the element calcium in the human body in relation to certain diseases. Many improvements are being made by these young chemists in the things we use today, such as artificial silk, rubber, and gasoline. Some are teaching and through their researches are pushing forward the boundaries of knowledge. All are doing work worthwhile. There can be no doubt as to the dignity and importance of their several daily tasks.

The young man in entering upon a life work wants to know what opportunities are ahead, what will be the reward of success. He should guard himself, however, against putting too much stress on the immediate compensation. Where will he stand in his profession in ten years is the more vital question.

The chemical industries of the country have grown at an amazing rate since the recent war. They are not only supplying the needs of this country, but are entering foreign markets against European competition. The demand for well-trained men exceeds the supply. And there is nothing in sight to indicate any falling off in the industry. The salaries paid are liberal and advancement rapid for successful men. The outlook is altogether favorable.

We must now ask, who should enter upon the life work of a chemist? Is a special aptitude required? To be successful he must be interested in things, must enjoy the marshalling of isolated facts, seeing the relation-

ships between them, and discerning the consequences of their arrangement into the several combinations possible. He must be able to use his hands and the processes of logical thought. He must have the spirit of research in its truest sense—the desire to solve puzzles and be able to experience a keen delight in a successful solution. Above all he must be an optimist—spurred on by temporary failure to final success.

Whatever the problem set before him there is always the drive to do the thing better than it has been done before. It may be a matter of control, development, production, or sales.

The young chemist must enjoy the exercise of his brain. Some pessimist has said that we are all willing to listen to others, to read good books, but most of us would rather lie down and die than think. I do not believe this is true. Arouse interest and even the meanest mentally likes to use his brains. Witness the great success of the cross-word puzzle and the latest fad, "Ask me another." We don't hear of students expressing this request in the class-room. But many people pay good money for a book of questions. Why? The answer, when found, may be a lesson to us who are teachers. If the problem or task arouses interest, and one really wants to know the answer, the labor and mental activity necessary will be forthcoming.

The dedication of this well-planned and equipped laboratory is evidence that the trustees of Wesleyan recognize the importance of chemistry in a university devoted principally to cultural education. I have stressed the significance of chemistry in industry and modern civilization, and have indicated also that something of the science should be a part of the equipment of every educated man.

This latter fact has been recognized in our colleges for many years, but as we study the results of the intensive teaching of science in the revolt against the former specialization in the humanities, we must admit that there has been much of failure in the effort to remake the college curriculum.

Whether or not the student is attracted to chemistry as a life work depends largely on the way in which his mind is opened up to the science. The nature of the first course is all important—is interest aroused or is the work necessary a disagreeable task? Certain teachers scoff at what others call inspirational teaching. They say it is a euphuistic expression for a policy of *laissez faire*. We must make the student work, give him difficult tasks to do against his inclination for the good of his mental and moral development. The good old days are passing, college students are becoming less and less serious in their work—we must stem the rising tide. But against this, the thoughtful man must be convinced that most successful lives can be traced back to the spark of inspiration.

Not so many years ago the first course in chemistry in college failed to

meet the situation. In the hands of the enthusiastic teacher, trained under the German system, at home or in Europe, in the methods of detailed research, and filled with the beauty of the newer theoretical ideas, the course became a maze of facts and hypothetical concepts. The beginner could not understand what it was all about. Osmotic pressure and ionic equilibrium were to be mastered for examination purposes by learning definitions which, in some books, were printed in bold-face type to let the student know which sentences to learn by heart. By many teachers the course was devoted to the training of the student's mind in logic. Facts were considered insignificant as information—the thing to do was to develop a mode of thinking. A grave error was made. We can reason only when we understand the facts. Little attention was paid to the broader aspects of the science, nothing said of the part chemistry has played in molding our economic and social life. What would the world be today without modern alloys, anesthetics, antiseptics, sulfite pulp and paper, synthetic nitric acid and ammonia, artificial fertilizers, coal-tar dyes, optical glass, synthetic resins, nitroglycerine, celluloid, rayon, and the countless other things that are now necessities in the world of commerce?

I heard a distinguished member of the Senate of the United States say that only recently had he learned what chemistry was all about and what it was doing in the world. He had studied chemistry at college and remembered a few mystic symbols like H_2O and H_2S but that was about all. He read a short time ago a simple story of chemical achievement and since then has been the champion of chemistry on the floor of the Senate.

College courses in chemistry soon became standardized, largely as the result of the appearance of certain textbooks better adapted to the advanced student than to the beginner having his eyes opened to a realm of thought foreign to anything in his past experience.

But happily, today, thoughtful teachers are seeking for a way to make the instruction of the college student in chemistry more vital and more lasting in its influence. They are asking themselves how they can best use the hours of the student's time over which they have complete control. What should a college education mean to a man? What is the aim? And how can the science of chemistry be used as one factor in helping to produce a trained and cultivated mind. It is a fascinating pedagogical problem. Experience teaches us that we must put aside many of the methods and aims that have become almost a tradition.

In my judgment, the selection of the content of the course in chemistry to be followed by the college student as a part of a liberal education should not be influenced by a desire to plan the work as a preparation for the subsequent education of the specialist in the science. This error has been made frequently.

I am gratified to say that the department of chemistry in this univer-

sity some years ago saw clearly the problem I have stated. And teachers interested in real education have watched what is being done here. It is a difficult problem and much study and trial of methods must be carried out in searching for a solution. But we are all sure that eventually the college course in chemistry will mean more than in the past, and that the student in the future will carry away with him a definite appreciation of science and the significance of chemistry. He will be a clearer thinker and a better citizen.

When a chemist hears the words Wesleyan University the name Atwater comes immediately to his mind. The laboratory here is known the world over for the fundamental contributions of a pioneer in one of the most important branches of chemistry. Atwater and his co-workers and the men inspired by his researches laid the foundations of a science which is today leading us to a more and more definite knowledge of the chemistry of the human body. The spirit of research has always been and is today associated with the chemical laboratory of Wesleyan. Such a happy state of affairs does not often exist in institutions devoted primarily to collegiate instruction. The influence on the students of teachers who are pushing forward the boundaries of knowledge cannot be over-estimated. Chemistry is alive and is growing rapidly. It is not solely a matter of textbooks and dictionaries. The student, on leaving college, should feel that the world is moving on, history is in the making, and he should be prepared to take his part in the advance.

The spirit of research should be jealously fostered by those in authority who control policy and provide the opportunity for the development of teachers who influence their students, not only by their presence in the class-room, but by their example as scholars.

Wesleyan University is to be congratulated on its new laboratory. The inspiration associated with this chemical workshop will lead men to take up a worthy life work congenial to themselves and of value to mankind.

I began this talk with a quotation from Paracelsus. Let me end it with one from J. J. Becker, a noted alchemist of the 17th century.

"The chemists are a strange class of mortals impelled by an almost insane impulse to seek their pleasure among smoke and vapor, soot and flame, poisons and poverty, yet among these evils I seem to live so sweetly that may I die if I would change places with the Persian King."

Tropical Medicine Association to Convene in Calcutta. The seventh congress of the Far Eastern Association for Tropical Medicine will be held in Calcutta sometime next December. The growing necessity of making the tropics habitable is attracting much attention to this field of research. When the scientific sessions are over the delegates will split up into tours one of which will visit the kala azar infested areas of Assam.—*Science Service*

REPORT OF THE SECRETARY OF THE DIVISION OF CHEMICAL EDUCATION

The Detroit meeting of the American Chemical Society, Sept. 5th–10th, was one of the most successful in the Society's history. The excellent program, cordial hospitality, and almost perfect weather made the guests reluctant to leave when the time came.

The Division devoted three half-day sessions to the reading of papers, all of which were well received. The average attendance exceeded 150, while over 200 were present at the symposium on The Popularization of Chemistry.

The Division sponsored three luncheons, to the last of which, due to the generous assistance of Mr. W. W. Buffum, the high-school teachers of chemistry in the Detroit area were invited as guests.

For several years members of the Division have tried in various ways to increase student attendance at national meetings of the A. C. S. This year, through the efforts of Professor O. E. Madison of the College of the City of Detroit, a number of undergraduate and graduate students were housed without charge for the duration of the meeting. Excellent rooms at a very nominal rate were also secured for others who registered with Prof. Madison. Similar plans will be laid for future meetings.

The meetings of the A. C. S. are of such inspirational value to students and teachers of chemistry that the readers of THIS JOURNAL are urged to plan actively to attend whenever physically possible. The next meeting will be held in St. Louis in April, 1928, and the one following in Boston in September of the same year.

Meeting of the Senate of Chemical Education

The regular meeting of the Senate of Chemical Education was called to order by Dr. Hopkins at 9 A.M., Sept. 6th, in Parlor A, Hotel Statler. Roll call: Alabama, A. S. Benham and J. R. Sampey; Georgia, J. S. Guy; Indiana, E. B. Carter (Proxy for F. B. Wade); Illinois, H. R. Smith; Kansas, F. B. Dains; Louisiana, H. W. Moseley; Maine, C. A. Brautlecht; Massachusetts, Laura P. Patten and G. J. Esselen, Jr.; Michigan, A. C. Stitt and G. W. Walker; Missouri, Herman Schlundt and Chas. W. Cuno; Nebraska, B. C. Hendricks; New York, H. A. Carpenter, E. M. Billings, and R. A. Baker; N. E. A. C. T., W. Segerblom; Ohio, M. V. McGill and Wm. McPherson; Oklahoma, C. L. Johnson; Pennsylvania, O. L. Shinn; Rhode Island, N. W. Rakestraw; S. Dakota, J. H. Jensen; *ex-officio*, B. S. Hopkins, L. W. Mattern, O. E. Madison, and R. E. Rose.

The chairman, treasurer, and secretary reported briefly. The treasurer was directed to publish his report in THIS JOURNAL.

It was voted that a symposium on Analytical Chemistry be held at the St. Louis meeting next April.

At the September, 1926, meeting of the Division, the following amendment to the by-laws was adopted, subject to ratification by the Council of the A. C. S.: "Sec. 2. Anyone who is a subscriber to the official organ of the Division and is a member of the A. C. S. is an active member of the Division." Secretary Parsons has pointed out that this is unconstitutional if intended to be exclusive, since any member of the Society may register in any Division of the Society. After discussion, the chairman was authorized to appoint a committee to formulate a new by-law covering membership and particularly associate membership in the Division.

The question of accrediting high schools on the basis of their courses in chemistry was referred to the Committee on Chemical Education with the recommendation that a special sub-committee be appointed to study it.

The chairman outlined the proposition presented to the Executive Committee of the Division a short time before the meeting by Dr. C. H. Herty of the Chemical Foundation. The Foundation has contributed generously for several years to the support of the JOURNAL OF CHEMICAL EDUCATION. In many other ways it has indicated its fundamental interest in the cause of chemical education in this country. On account of the apparent restrictions which have arisen in regard to the funds of the Division of Chemical Education, the Chemical Foundation is unable to continue its financial support of the JOURNAL OF CHEMICAL EDUCATION. The Foundation recognizes that the JOURNAL is the property of the Division of Chemical Education and that the Division is free to seek aid elsewhere. However, should the Division so desire, the Foundation would be glad to continue its support of the cause of chemical education by assuming entire responsibility for the JOURNAL.

The Executive Committee had spent several hours considering the various phases of the matter and unanimously recommended to the Senate that the JOURNAL remain the property of the Division of Chemical Education. The chairman read the following note from Secretary Parsons of the A. C. S.:

> The Executive Committee and Directors in joint session, are unanimously appreciative of the attitude of loyalty to the Society, shown by the Executive Committee of the Division of Chemical Education, in their conference with the President and Secretary, on the evening of September 4th, as reported to us; express their realization of the good work of their Division in the cause of Chemical Education; recognize fully the importance of that work to the cause of American Chemistry and pledge their best endeavors to enable the Division to publish the JOURNAL OF CHEMICAL EDUCATION under their control and auspices.

Following a very frank discussion, it was unanimously voted that "it is the sense of this body that the financial and editorial management of the JOURNAL OF CHEMICAL EDUCATION should remain with the Division of Chemical Education of the A. C. S."

A committee consisting of W. Segerblom, S. R. Brinkley, and A. P. Sy was appointed to draft suitable resolutions, expressing: (1) to Mr. Garvan and the Chemical Foundation our sincere appreciation of past encouragement and support of the JOURNAL OF CHEMICAL EDUCATION; (2) to the present editor and business manager of the JOURNAL our sincere appreciation of their fine work; and (3) to the President and Secretary of the A. C. S. our appreciation of the confidence of the Executive Committee and Directors of the A. C. S.

It was unanimously voted that questions pertaining to the actual conduct of the JOURNAL be referred with power to the Executive Committee of the Division in consultation with the Executive Committee of the A. C. S.

The question of securing representation in the Senate from the states of Wyoming and Texas was referred to the Local Sections of the A. C. S. in these states.

The officers of the senate were instructed to work out a procedure whereby the systems of rotation of senators from various states be made as uniform as possible.

Action on the proposed Institute of Chemical Education was deferred. (The report of the Executive Committee of the A.C.S. appeared on pages 1299–1302 of the October issue.)

Progress reports from the following standing committees were accepted and the committees continued: Coöperation in Prize Essay; Nomenclature; High-School Research; Research on Problems of College Chemistry Instruction; Aids to Visual Chemical Instruction.

These reports will be published from time to time in THIS JOURNAL; that portion of the report of the committee on High-School Research which led to further action by the Senate appears below.

Through correspondence with authors and the Editor of the JOURNAL OF CHEMICAL EDUCATION, the committee has had the plates held for several published investigations which bear upon high-school chemistry instruction. These articles are for the most part the result of careful and intensive study of some limited problem and represent the type of investigational work which the committee wishes to see encouraged in every possible way. In the near future it is hoped that these papers and others to be published may be reprinted under one cover for (*a*) use in courses dealing with the teaching of high-school chemistry, (*b*) distribution to high-school and college teachers who may not be familiar with the activities of the Division of Chemical Education in furthering the improvement of chemistry instruction, and (*c*) circulation among graduate students, university professors and others who may be in position to encourage, supervise or conduct investigations upon the teaching of high-school chemistry.

The committee was authorized to obtain estimates of the cost of publishing these reprints under one cover.

J. H. Jensen made a progress report for the Committee on High-School Apparatus. The report was accepted and the committee continued.

W. Segerblom reported for the committee appointed in April to formu-

late several outstanding problems in Chemical Education. This report appears at the close of these minutes. The committee was continued.

Adjourned, 11:50 A.M.

R. A. BAKER, *Secretary*

Business Meeting of the Division of Chemical Education

The meeting was called to order by Chairman Hopkins at 9:30 A.M. Sept. 9th, Ball Room, Hotel Tuller. Roll call: R. A. Baker, S. R. Brinkley, A. C. Burr, J. S. Guy, B. T. Hill, B. S. Hopkins, J. H. Jensen, O. E. Madison, Laura P. Patten, Otto Reinmuth, W. Segerblom, J. W. Sullivan, A. P. Sy, J. A. Yates.

The minutes of the meeting of the Senate, Sept. 6th, were read and unanimously approved.

The nominating committee, consisting of O. E. Madison, M. V. McGill, and E. M. Billings presented nominations for chairman, vice-chairman, secretary, and three members of the executive committee. The following were elected: *Chairman*, B. S. Hopkins; *Vice-Chairman*, H. R. Smith; *Secretary*, R. A. Baker; *Executive Committee:* Wm. McPherson, W. Segerblom, and L. W. Mattern.

The question of the terms of office of the officers of the Division was referred to the Executive Committee for a report at the St. Louis meeting in April, 1928.

The chairman announced the appointment of L. J. Wood of St. Louis to act as assistant secretary until after the April, 1928, meeting.

Adjourned, 11:05 A.M.

R. A. BAKER, *Secretary*

Report of the Resolutions Committee

1. To the President of the American Chemical Society:

In accordance with action taken at the business meeting of the Division of Chemical Education of the American Chemical Society at the Detroit meeting, the Committee on Resolutions hereby puts on record that the Division and the Senate of Chemical Education appreciate most sincerely the touching expression of confidence received from the Executive Committee and the Directors of the American Chemical Society, and pledge anew their continued loyalty to the parent organization.

2. To Mr. F. P. Garvan:

In accordance with action taken at the business meeting of the Division of Chemical Education of the American Chemical Society at the Detroit meeting, the Committee on Resolutions hereby puts on record an

expression of the genuine appreciation by the Division of Chemical Education and its officers for the encouragement and support which Mr. Garvan and the Chemical Foundation have so generously contributed to the cause of chemical education as embodied in the Division of Chemical Education and the JOURNAL OF CHEMICAL EDUCATION.

3. To Dr. Neil E. Gordon and Mr. E. M. Billings:

In accordance with action taken at the business meeting of the Division of Chemical Education of the American Chemical Society at the Detroit meeting, the Committee on Resolutions hereby puts on record that the Division of Chemical Education and the Senate of Chemical Education recognize and appreciate the large amount of time and effort that Dr. Neil E. Gordon and Mr. Erle M. Billings, editor-in-chief and treasurer-business manager, respectively, have spent in establishing the JOURNAL OF CHEMICAL EDUCATION and in bringing it to its present high standard and wide circulation.

S. R. BRINKLEY
A. P. SY
W. SEGERBLOM

Report of Committee to Formulate Five or Six Outstanding Problems in Chemical Education

This committee is the outcome of discussion at the Richmond meeting of the Division last April. Since three of the five members appointed on this committee by Chairman Hopkins were present at the Institute of Chemistry at State College, Pennsylvania, during the summer, these three (Messrs. Currier, Whiteford, and Segerblom) held a number of conferences, laid out general plans of procedure, and drew up a tentative list of problems.

In spite of the fact that there are probably more problems that need solution in the teaching of college chemistry than in high-school chemistry, because most high-school teachers must have had courses on teaching methods and practice in teaching before they can get a job, still it was felt that our first list of problems should include those relating primarily to the teaching of chemistry in high school.

It was felt that this committee should make its report at the Detroit meeting, in order that: (1) the chairman of the Division might appoint the special committees to study the problems selected immediately after his election, and (2) the special committees might have opportunity to complete their investigations during the coming school year and make their reports before next summer's vacation—and, if possible, at the spring meeting of the Division.

The chairman of the committee wrote to the other two members, Messrs. Hessler and Littleton, asking each to draw up a list of outstanding problems. Each submitted 4 problems. These eight problems were combined with the 14 problems drawn up at State College and the final complete list submitted to all the committee members for the selection of the 5 or 6 outstanding problems.

The committee felt that it should consult with Dr. E. R. Glenn, chairman of the Committee on Research on Problems of High-School Chemistry Instruction, and with Dr. S. R. Powers, chairman of the Committee on Research on Problems of College Chemistry Instruction, in order that there might not be any overlapping or encroachment on our part on work of their standing committees. On request by our committee, Dr. Hopkins, chairman of the Division, authorized such coöperation.

By the time this report is in press the final selection of outstanding problems will have been submitted to the chairman of the Division and the special committees will probably have been appointed.

The list of suggested problems from which the final selections will be made is appended.

SUGGESTED PROBLEMS

1. Organization of work of first year of high-school chemistry around a few major topics. (See work of Harry Carpenter of West High School, Rochester, N. Y.)
2. Study of reduction of equipment costs, including that of furniture.
3. What order of presentation of laboratory work and recitation gives best results?
4. Trend of enrolment in chemistry.
5. How are teachers being prepared in college for teaching in high school? (Major in chemistry and minor in education or vice versa?)
6. Average tenure of science teachers in high school compared with that in other subjects.
7. How best sell chemistry to the community?
8. In what colleges can a person get a Ph.D. in the chemistry department for work on the problems in teaching of chemistry?
9. What colleges have small sections in chemistry instead of lectures to large crowds? Should the small section plan be recommended?
10. What high schools have small sections in chemistry instead of lectures to large crowds? Should the small section plan be recommended?
11. Some problems relating to Freshman (elementary) chemistry and their solution.
12. What colleges use the Iowa (or similar) Placement Test and with what result?
13. Purpose of chemistry in high school: (*a*) preparation for college,

or (*b*) preparation for culture or community service; and best method for the accomplishment thereof.

14. Should chemistry as taught in the high school be along general lines so as to interest the student in further study in this subject, or should it include a quantitative idea so that the student could do routine simple analyses according to detailed instructions?

15. How much stress should be placed on problems?

16. How much stress should be placed on equations?

17. How much stress should be placed on the electron theory?

18. To seek to set up a higher standard of attainment among chemistry teachers: (*a*) by insisting on a more adequate preparation of high-school teachers of the subject, and (*b*) by urging Boards of Education to give their science teachers the time and equipment necessary for good work.

19. To seek to arouse a professional spirit among high-school chemistry teachers as a group: (*a*) by urging teachers to overcome the professional isolation which now exists in many districts, (*b*) by encouraging the taking and reading of chemical journals, (*c*) by bringing to the attention of Boards of Education the need for teachers to attend group educational meetings, and (*d*) by organizing regional meetings designed especially for teachers of high-school chemistry.

20. To encourage the teaching of simple, fundamental ideas of chemistry.

21. To encourage high-school teachers of chemistry to carry on simple (if necessary) laboratory work of their own, in order to convince their students objectively of their belief in such work.

22. To what extent are candidates for degrees in non-teachers' colleges getting instruction in teaching methods especially suited to chemistry?

A. J. CURRIER
J. C. HESSLER
L. R. LITTLETON
G. H. WHITEFORD
W. SEGERBLOM, *Chairman*
in consultation with
E. R. GLENN
S. R. POWERS.

Meeting of the Executive Committee of the Division of Chemical Education, Washington, D. C., October 16, 1927

Present: Hopkins, Gordon, Segerblom, Mattern, Billings, and Baker.

At the Detroit meeting the question of the conduct of the JOURNAL OF CHEMICAL EDUCATION was referred, with power, to the Executive

Committee of the Division, in consultation with the Executive Committee of the American Chemical Society.

After a preliminary discussion of the problem before it, the Committee conferred with President Rosengarten and Secretary Parsons of the A. C. S. The President and Secretary stated to the Committee that, (1) so long as the JOURNAL is a publication of the Division, the latter should control it, (2) all funds received by the Division, including salaries paid to officers, should be donated to the American Chemical Society or to the Division directly, to be expended under supervision of the latter. It was the unanimous opinion of the group that it would be expedient, for the present at least, to turn over to some outside agency the business management of the JOURNAL (advertising, printing, distribution, etc.), leaving the editorial management in the hands of the Division.

Following the conference with the President and Secretary, the Committee voted as follows: (1) That the Division handle its own finances directly. (2) That the Division retain full editorial control of the JOURNAL but that its publication be arranged through some outside agency. (3) That the cost of editing the JOURNAL be carried by the Division. (4) That the Division publish annually in the JOURNAL OF CHEMICAL EDUCATION an account of all funds which come into its treasury.

Relative to the business management of the JOURNAL, proposals were considered from the Williams and Wilkins Company, the Mack Printing Company, and the Chemical Foundation, Inc., the last being contingent upon the Division's assuming entire charge of its finances. After considering these three proposals, it was voted, with the approval of the President and Secretary of the Society, to accept that of the Chemical Foundation to take over the business management of the JOURNAL and to provide the Division with sufficient funds to meet its editorial budget.

The Secretary reported the unanimous ballot of the Contributing Editors for Dr. Neil Gordon as Editor of the JOURNAL OF CHEMICAL EDUCATION for another term of three years, beginning July 1, 1928.

R. A. BAKER, *Secretary*

Ultra-Violet Radiation Spoils Food for Yeast. The old adage, "What is one man's meat is another's poison," has been well illustrated by the effects of ultra-violet rays on the sugar solutions in which yeast cultures are grown. Experiments performed at Ames, Iowa, by Drs. J. W. Woodrow, A. C. Bailey, and E. I. Fulmer of Iowa State College, show that if the flasks of nutrient liquid in which the minute plants are subsequently to be grown are exposed for a number of hours to the invisible radiations, they become definitely poisonous to the yeast cells, markedly decreasing their rate of growth. This is completely contrary to the results obtained by irradiating the food of animals, which have been shown to generate beneficial vitamins under such treatment.—*Science Service*

THE NEW-TYPE METHODS OF TESTING—A CRITICISM

W. F. HOYT, STATE NORMAL SCHOOL AND TEACHERS COLLEGE, PERU, NEBRASKA

There are many indictments against the so-called new-type methods of testing in chemistry. These methods are not scientific. Science is *organized* knowledge, not a collection of facts and words. During the past century and a half scientists have been patiently and laboriously discovering facts and piecing them into generalizations, hypotheses, theories, principles and laws, and from them forming a great highway of science through the fields of nature, upon which the student could "run and not weary, walk and not faint." The new-type testers dig up the blocks of this paved highway and hide a bugbear of true and false statements behind each one. That may be an amusing pastime to the tester, but it cannot be dignified by calling it science. True-and-false questions constitute a prize exhibit of fallacious psychology. A beginner should never have a false statement put before him, especially by the teacher. The mature and trained student with a solid foundation upon which to stand and a background of chemical knowledge may safely encounter a few such questions and be able to separate "the sheep from the goats."

Science is constantly classifying chaotic facts into an orderly system, but the new-type tester, reversing the process, breaks up these orderly systems into a chaos of facts and words. A thousand facts cannot make or begin to make a chemist, but a score or two of coördinating principles, illustrated by problems and processes founded upon these principles, will make a start at producing an amateur scientist. A hundred or several hundred questions answered by a word or a mark are far too many for a rational test, but ten or twenty hypotheses and problems illustrating chemical principles are not.

The new-type tester does all the connected thinking and coördinating, leaving the student only snap judgments and word answers. A true test is not a Cook's Tour nor a "follow-your-leader" game of frenzied progress through the fields of science. Science requires unhurried thinking and reasoned judgment. The method of grading or ranking is faulty pedagogy, based upon a hastily formulated "law of averages." Is it not thinkable, at least, that all of the guesses may be right or all wrong, instead of a fifty-fifty chance of being right or wrong? There is no "average" student. A man or a child is not a machine, but a bundle of tremendous possibilities to be developed. Each student is entitled to a judgment based upon his own attainments, not upon a hypothetical average. I know quite well a family of five children, all of them alive and well, the youngest of whom is sixty-three years old. By the average expectation of life, two or three of them, at least, ought to be dead long before this. When the

new-typers come into their own, undoubtedly all men and women will be buried according to schedule!

The tragedy of the new-type tests is that they set the standards of teaching—"'tis true, 'tis pity, and pity 'tis 'tis true!" My experience with the new-type teachers is that they "get nothing across." The head of the department of chemistry in a great university, in discussing the attainments of high-school students in chemistry, remarked to me, "Isn't it awful? I would rather catch them wild!" Another teacher of teachers, and an author of methods of teaching chemistry, declares he would rather his pupils came into his classes entirely innocent of all chemical knowledge than with the average high-school equipment, because in that case they would not have to unlearn so much. High schools suffer more than the colleges and universities from the new-type teachers. Every callow—the callower the worse they are afflicted—new psychologist and prospective teacher comes out with a conviction that his first duty is to psychoanalyze his pupils. May heaven pity their defenseless children! Only God can psychoanalyze a human being. The functions of a teacher are not psychoanalysis or untangling complexes, but to be the guide, sympathizer, and, if possible, the inspirer of his pupils. All *great* teachers have been inspirational.

Is chemistry too difficult for high-school students? I am convinced it is not. Chemistry, when rightly taught, is far easier than many other high-school subjects. I had occasion to speak before a body of chemistry teachers recently, and I startled the high-school teachers by saying, "The average high-school teacher aims at nothing, and hits it!" I see no reason as yet for modifying that statement. I have had occasion to compare and contrast the new type with the "old," in recent years. A contributing high school employed new-type teachers for two years. The classes averaged about thirty each year. Out of these two years but one student took advanced chemistry, and this one had to have the A, B, C's of chemistry drilled into him throughout his later course. In the two following years the "old-type" teachers were employed, with approximately the same number of chemistry students. Of these, however, from a half to three-fourths presented themselves for advanced chemistry, and these proved "up on their toes and ready to go" ahead without drilling on the elementary fundamentals. A superintendent in a small town, who is also a teacher of chemistry, said he recently tried the new-type test in his classes with disastrous results. The poorest student in his class, who knew practically nothing of chemistry, secured the highest grade. Apparently a scientist, amateur or expert, is not a good guesser.

The new-type tests were prepared by psychologists and for psychologists with scant knowledge of the science and less knowledge of the problems of teaching the science and still less of vital experience of asso-

ciation with chemical students in the class-room and laboratory. J. McKeen Cattell, virtual dean of American psychologists, author of many scientific books and editor of various scientific magazines, in his presidential address to the A. A. A. S. at its annual session at Kansas City, said in a jovial way, "It has been generally known for many years that psychologists had lost their souls, but now it is feared that they are losing their minds!" He must have been referring to the new-type psychologists, and, if so, it is more of a grim fact than a laughable jest. I have been rallied for the ancient flavor of my psychology for quoting with approval Isaiah XXVII, 9–10: "Whom shall he teach knowledge.....for precept must be upon precept, precept upon precept, line upon line, line upon line, here a little and there a little!" It is as ancient as the decalog. What a pity that the great prophets and teachers of Israel did not have the advantages of the new-type psychology! Think how the Sermon on the Mount might have been improved! Agassiz, Horace Mann, and our own beloved Bessey did very well in their times, but we must admit they were pre-Freudians. How very sad that they had not the benefits of the new-type tests so that they might psychoanalyze their pupils! The new testers assume that all the great psychologists substantiate their contentions. Actually the psychologists are fully as united as the forces of China—no more and no less. I have been challenged to give an example of what I shall call a "Rational Test," and defend it openly and show that it lacks the defects of the new-type tests, so here it is.

A Rational or Old-Type Chemistry Test

1. Define: chemistry, energy, force, element, mixture, solution, radical, anhydride, allotropy, isomers, isotopes, acid-salt. (Answer any ten.)

2–3. Find the weight of the salt formed and the volume of the gas collected by the action of HCl on 4 grams of $NaHCO_3$, laboratory temperature being 17° Centigrade and the pressure being 29 inches. (N. T. P. being 273° Abs. and pressure being 30 inches.)

4. What volume of air will be necessary for the complete combustion of 10 liters of gasoline gas, C_7H_{16}, ignoring temperature and pressure?

5. Tabulate the phosphorus series of acids and their calcium salts, giving the prefixes and suffixes of each acid and salt.

6. Outline the modern conception of the states of matter and the forces involved.

.....

7. Complete the following equations: NH_4NO_2 heated = ; $C_6H_{10}O_5$ (cellulose) burned = ; $HNO_3 - H_2O$ = ; $FeCl_3 + K_4Fe(CN)_6$ = .

8. Tell how to form H_2; O_2; N_2; and CO_2, writing the formative equation for each.

9. Reduce —15° Centigrade to Absolute and Fahrenheit; 77° Fahrenheit to Centigrade and Absolute; 233° Absolute to Centigrade and Fahrenheit.

10. Name, tell if acid, base or salt and give valence of each element and radical: H_2SO_3; $AgNO_3$; NH_4OH; K_2CrO_4; $K_2Cr_2O_7$; Na_2S; $FeCl_3$; $Al(C_2H_3O_2)_3$; $Ba(OH)_2$; BaS_2O_3.

11. Tell the common way to form acids, bases and salts, and write formative equations for H_2S, $(NH_4)_2S$, and $Ca_3(PO_4)_2$.

12. How much lye (impure NaOH) will it take to react fully with 10 lb. of stearin $C_3H_5(C_{18}H_{35}O_2)_3$ in making of soap.

If but one hour can be taken for the test, answer five out of 1 to 6. If an examination of two hours' duration answer ten out of 1 to 12, five in each division.

There is not a catch or an inconsequential question in the above list, and every one requires a knowledge of some principle of chemistry. There is not a pin-point where you can press in a guess, and there is not an "essay" required in the list. I stand or fall on a comparison of these questions with the new-type test.

New Color Test for Toxins Will Save Labor. A color test that will speed up the commercial production of diphtheria and tetanus toxins, if further tests bear out preliminary investigation, has been discovered by Drs. Lucy Mishulow and Charles Krumwiede of the New York City Health Department.

Up to the present time the standardization of toxins, which play such an important part in modern therapeutics, has been based on a system by which the strength of a batch of toxin could only be determined by trying it out in laboratory animals. This procedure involves inoculation of many guinea pigs, endless calculations and observations and the keeping of innumerable records. Animal tests give satisfactory results but chemical tests when possible are much more rapid and exact.

In the process of trying out different reagents to detoxify diphtheria toxin Drs. Mishulow and Krumwiede found that the chemical compound gold chloride gave an interesting color reaction when mixed with the toxin. The investigators then proceeded to determine if a quantitative relationship existed between the strength of the toxin and the color produced. Their results indicate that such is the case. By means of the color tests they have been able to estimate the strength of the toxins and have found that this estimation checks approximately with the toxin value obtained by animal tests. If subsequent research bears out these results another great discovery will have been added to the credit of modern medicine.—*Science Service*

Leaves Reflect Portion of Light They Receive. Leaves are by no means 100 per cent efficient in their work of making food with the aid of captured sunlight. In addition to giving off as lost heat a part of the energy they absorb, they also fail to absorb part of the light that falls on them, simply throwing it back by reflection. Researches on this reflection loss by leaves were reported before the recent meeting of the National Academy of Sciences by Prof. Charles A. Shull of the University of Chicago.

Different leaves reflected different proportions of the light that fell upon them, Prof. Shull found, and the same leaf reflected light of different colors in different percentages. Thus, the upper surface of a silver poplar leaf reflected 7.5 per cent of one of the violet hues, and 20 per cent, or nearly three times as much, in the yellow-green part of the spectrum.

The upper and lower surfaces of the same leaf have very different reflecting powers. The same silver poplar leaf, which is dark green above but shining white beneath, reflected 8.5 per cent of the deepest red rays from its upper surface, and 50 per cent of the same rays from its under side.

Autumn coloring had a great influence on the reflecting power. The red leaves of the woodbine reflected nearly twice as much red light as they did of violet; but their total reflection was far less than that of the bright yellow birch leaves, which reflected over 40 per cent of the incident light, as against only about 13 per cent for the woodbine leaves.—*Science Service*

NEW-TYPE TESTS MEET A NEED

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It has been asked, "Why can we not grade upon the score of things pupils can be reasonably expected to know, instead of the thousand and one things that are not relevant? Why ask the pupil to answer a hundred twenty-five questions when the test could easily be concentrated upon ten?"[1]

The following criticisms have been made of new-type tests and the psychology back of them: "Word answers . . . require guessing. . .True-false tests make our tasks as teachers . . .much more difficult. . . A jumble of true-false statements (is). . . jazzing our science."[2] "True-and-false tests are shining illustrations of rotten psychology. . . (What justice in) right guesses . . . (minus) wrong guesses for the score(?)"[1] "Word tests do not take into account . . . (that) science is based upon principles, laws and problems."[2]

Some psychology suggested, presumably as a substitute for the "bad psychology:" "A child does not learn . . . by studying . . . faulty (content) . . . The growing child is not a reasoning animal but one of sense impressions. . . The child . . . should not be faced by judgments that try the adult mind. . . Reasoning comes after a foundation of right sense impressions." And finally, "The psychology of teaching has not changed for the better, apparently, in the last three thousand years."[1]

Of special interest to teachers of chemistry: "Up to within ten years chemistry examinations (in Nebraska) have been farces . . . much like (demands for) lists of facts from a World Almanac. . . . Not to *balance* equations . . . is to sidestep the most essential thing in equation writing."[2] "Give the pupil the bare problem for solution by principles and formulas of science."[1] (Such a problem is). . . "What weight of salt formed and volume of gas collected should be obtained by the action of 4 grams of $CaCO_3$ with HCl, the laboratory temperature being 19°C. and the pressure 29.2 inches? If a student can solve that (problem) he has a fair knowledge of beginning chemistry."[2]

Some characteristics which any well-built test should have are: objectivity, comprehensiveness, reliability, and that it consume a minimum of time both in its administration and scoring. Further, the type of test should be determined by the purpose of the examiner. It may be used as a teaching device, a measuring scale, or a diagnostic instrument. These are mentioned as points of departure for what follows.

Tests for a large number of different groups, in order to give comparable scores, should be objective. By that I mean that they may be rated by

[1] W. F. Hoyt, *Nebraska Educational Journal*, **7**, 307–8 (1927).

[2] W. F. Hoyt, communication to author.

different readers with a high degree of agreement. It is quite generally agreed that new-type tests—true-false among them—meet this standard much more nearly than does the ten-question essay test. The time required to administer a new type test, as well as to rate it, is much shorter than the conventional "essay" test. One writer,[3] who has studied testing almost as much as Dr. Dayton C. Miller has studied ether-drift, says: "10 to 20 minute examinations of objective type are very much more reliable than 5 to 10 question traditional examinations which require 30 to 60 minutes."

Again, the more content a test can cover, the more comprehensive it is; in other words, the more certain a reader can be of the spread of the student's knowledge and the surer he is that that student is or is not worthy of recognition. Testing in education, as I understand it, is like testing in an analytical laboratory. Unless the sample includes all ingredients of that which is tested the result does not mean much. Other things being equal, isn't a test of one hundred twenty-five items more likely to include all "ingredients" of chemistry than a ten-question test?

In preparing tests of achievement, especially for contests, I have assumed it was not the purpose of the test to teach and that it was immaterial whether it had any diagnostic value or not. I think there are those who agree with me that it is better that these tests be, if possible, entirely shorn of teaching value, or at least that it would be unfortunate for the test to contain so few items, ten questions for instance, that interested students be tempted to resort to cramming through the use of them. Certain it is, if the spread is made great enough, such use of them in review before the test would require a general review rather than a lop-sided cram.

True-false tests seem to be very disturbing to some teachers. They, no doubt, have their limitations but I cannot quite see in them all that those teachers fear. Commonly, no test contains more than one, out of four or more parts, of the true-false type. The chief criticism of them seems to be summed up in "guessing" and "wrong (first) impressions." Guessing is possible in any test but a *double penalty* upon each error, as stated in true-false tests, would hardly encourage guessing by any *thinking* student. The purpose of "rights minus wrongs" is questioned. A real guesser, according to the law of probabilities, for a hundred or more items, will guess as many wrong as right. His score, consequently, will be zero as all certainly will agree it should be.[4] In regard to "wrong first impressions," it is assumed in achievement tests that right impressions have already been made long before the test is taken. If not, the student

[3] G. M. Ruch, "The Improvement of Written Examination," p. 114, Scott Foresman & Co., 1926.

[4] D. G. Paterson, "Preparation and Use of New-Type Examinations," p. 37, World Book Co., 1925.

should not be allowed to compete in such a test. On the other hand, modern psychologists do not agree with those who insist that the child must become an adult before he begins to make choices or decisions between right and wrong.

It is well said, "chemistry is a science based upon particular terms, principles, (and) laws." It has also been said "(one) would not suspect any such (principles, laws, terms) for science (in true-false tests)." An examination of the true-false requirements from one such test[5] shows that thirty-two out of fifty of them call into use, either a significant term such as: allotropic form, electrolysis, hydrolysis, equilibrium, ionization, electrolyte, anhydride, etc.; an important principle as: order of activity principle, electron exchange, stability of compounds, oxidation-reduction, solubility controls, reversible reaction controls, etc.; or some law including: the periodic law, Raoult's, Avogadro's, Charles', and Henry's. In fact, almost as many terms, principles, and laws of chemistry are tested in the true-false part of this test as in *all* the other three-fourths of the test. For tests that the writer has examined, which use true-false items, the above is not exceptional.

In this same connection, it is interesting to note that during the last ten years the tests in Nebraska, referred to in the introduction of this paper, have gradually been using more and more new-type requirements. Is it possible the critics do not recognize such requirements unless they are labelled?

Perhaps some attention to the character of old-type requirements and claims made for them may be helpful. A favorite requirement, as suggested in this paper's introduction, is a problem involving the arithmetic of chemistry. Analysis of the problem referred to shows the following elements of difficulty: Two products, calcium chloride and carbon dioxide; four formulas; atomic weights of four elements; knowledge of the molecular weight principle; arithmetic (addition, multiplication, and division); conservation of weight principle, *i. e.*, conscious or unconscious knowledge that *all* the calcium in the carbonate, for instance, is found in the product calcium chloride; the principle of gram molecular volumes; memory of Boyle's law and ability to apply it; memory of Charles' law and ability to apply it; implying relationships of thermometer scales; and the concept of an absolute scale. This totals some eighteen items. Should scaling a student's reaction to this problem take note of these difficulties? Will all readers of answers to such a requirement weight these elements of difficulty the same? If not, there is no need to suggest the possibility of an almost unbelievable number of ratings. Objectivity of a test departs when such requirements are used.

[5] Eric R. Jette, Form A (Experimental edition), "Columbia Research Bureau Test in Chemistry," 1926.

Then from another angle, failure to get the correct weight of the salt may be due to any one of ten errors. Failure to get the correct volume of gas may be due to any one of sixteen errors. Put in another way, one mistake out of ten difficulties will give a wrong weight result. Shall we say his knowledge of chemistry revealed by this problem is zero when it may be 90 per cent? Or, again assuming due weight is given to each of the ten difficulties, is it *fair* to "stack the cards" against a student by making a correct answer to one element entirely dependent upon a correct answer to some prior element; especially when the whole question's rating involves ten per cent of his total score?

Note, too, that even though "not to balance an equation . . . is to sidestep the most essential thing in equation writing" both parts of this "ideal problem" may be solved correctly without attention to "balancing equations."

Again, does this problem with its twenty, more or less, elements of difficulty represent a fair sampling of the science of chemistry? Does a student who can solve this problem have "a fair knowledge of beginning chemistry?" Of the eighteen elements listed above, how many are, in the strictest sense, chemistry? Can more than eleven be so classed? How many such principles does the science of chemistry have? How about the order of activity principle, the principle of solution activities, the principle of reversible reactions, the principles of separation, the principle of heat effects and numerous others? There are some teachers, I am sure, who would join me in saying that such a problem is just about as adequate as a sampling of high-school chemistry as an analysis of *skim* milk in representing the contents of *whole* milk. Drill upon such problems may (?) get the less than twenty per cent[6] of high-school chemistry students ready for more college chemistry. Such may have been the type of questions for Regents Examinations as they were twenty years ago. (They are now using new-type tests, I understand.) But what of the eighty per cent of high-school chemistry students who are at the end of that course forever done with chemistry? Have they anything from this that will answer, in any way, the aims of secondary education?

The teachers of chemistry, in common with all teachers of science, pride themselves that science trains its devotees to have a scientific attitude toward life's problems. It certainly is not presuming to assume that this problem of testing is, for us teachers, something of a "life problem." We pride ourselves that we do not condemn an idea or principle without giving it a trial, especially when it comes with as good credentials as new-type tests have. We are or should be willing to try out such

[6] John S. Chambers and B. Clifford Hendricks, "Chemistry Teaching in Nebraska," unpublished, 1927.

tests to see if they breed guessers. As scientists we are open-minded to what specialists in education have been doing to show us some of the complexities of testing devices just as specialists in our chemical field have, in the last seventeen years, revealed the marvelously complex structure of the atom. I am sure we are all willing to concede that not all the investigational agility of our country is found in the chemistry laboratories and that there are men and women, who have made a study of testing, who have findings which merit our attention even with reference to true-false scales. We teachers of chemistry are teaching a growing science and are likely to be so busy keeping up with its progress that we have little time to keep abreast with the progress of educational psychology and measurements. Our only salvation then, as I see it, is to let their experts help us just as we let a medical expert help us with our physical needs. If we do so, though, it may become necessary for us to concede that "the psychology of teaching has . . . changed some for the better, . . . in the last three thousand years."

In conclusion: it has been shown that each old-type test question often involves many elements of difficulty. Since each question commonly counts one-tenth of the total score, each element of difficulty should (but probably does not) receive conscious attention at the hands of the one scoring it. This undoubtedly accounts largely for the lack of objectivity in scoring such questions.

It cannot be proved that new-type tests make demands *less* relevant than do the old-type tests, and it has been shown that fair sampling and comprehensiveness demand a hundred twenty-five, more or less, requirements rather than ten.

"Word answers" do not "*require* guessing" though they *may* be guessed. Modern tests do not encourage guessing because directions for rating, which are plainly before the student, penalize such responses.

Modern tests, including true-false, rather than making "our tasks . . . more difficult" are reducing our drudgery, saving to us much time formerly spent reading essays which were called examination papers.

There is no more reason to say true-false tests are "jazzing" our science (teaching) than that the electron theory is "jazzing" our theory of atoms.

It has been shown that modern tests "take into account the fact that science *is* based upon principles, laws and problems" quite as much as old-type requirements.

Not all tests are intended as teaching instruments. False statements in tests are never intended to produce first "impressions." Such criticism of them, then, is beside the point. There is, at least, a shade of difference between reasoning and thinking. Modern psychologists[7] say the child is a thinking "animal." That thinking comes *with*

[7] Dewey, "How We Think," p. 66, D. C. Heath & Co., 1910.

a foundation of right sense impressions rather than *after*. They also aver that a child learns to make correct choices by practice, deciding between right and wrong or even true and false.

In view of these facts and in no inconsiderable measure supported by the growing use of new-type tests I cannot but conclude that new-type tests are meeting a real *need* in our teaching procedure.

Note: Readers who may be interested are referred to Dr. S. R. Powers' "General Chemistry Test," either Form A or B (The World Book Co., Yonkers-on-Hudson, N. Y.) or H. L. Gerry's "Tests of High-School Chemistry," either Form A or B (Harvard University Press, Cambridge, Mass.), for examples of the new-type tests in high-school chemistry. Similar tests in college chemistry are given by Dr. Hildebrand in an article entitled: "Final Examinations in General Chemistry," THIS JOURNAL, 3, 313–8 (March, 1926).

Rats Made Immune to Pneumonia. Experiments in immunization against pneumonia by the feeding of acid-killed pneumonia germs are being watched with interest by the New York City Department of Health, according to Dr. William H. Park, director of the Bureau of Laboratories.

Although the Health Department is taking no part in the experiments it is following carefully the work being done by Dr. Victor Ross of Bloomfield, N. J.

With rats for the subjects the experiments have proved successful. The rats were fed pneumonia germs which had been killed by hydrochloric acid. They reacted by building up a resistance to the dead germs which, it was found, was sufficient to immunize them against injections of living pneumonia germs. It was established further that the age of the rats was no factor in their ability to build up a resistance. Both adult and young rats were used in the experiments and young and old alike were made immune.

Because of the success with the rats the experiments will be carried a step nearer the human race and will next be made on monkeys.—*Science Service*

Active Part in Tuberculin Protein in Its Nature. The riddle of the chemical nature of tuberculin, the substance used for detecting tuberculosis in cattle, is a step nearer solution through researches reported before the recent meeting of the National Academy of Sciences by Dr. Florence B. Seibert of the University of Chicago.

There has always been a question, Dr. Seibert stated, whether the specifically potent factor is a protein or merely an infinitesimal amount of some very highly active substance attached to the protein. The difficulty in solving problems such as this has been due to the fact that the purification of proteins is one of the most difficult of all tasks in chemistry. In her laboratory, however, efforts to obtain a purified product have succeeded in producing an active protein in crystalline form. One of the surest tests of chemical purity is obtained when crystals come out of a solution; mixed materials do not crystallize.

"The crystalline protein is purer and therefore more potent than the original water-soluble fraction of tuberculin from which it is made," Dr. Seibert said. "One-tenth of a milligram of the original fraction is required to produce a maximum skin reaction in tuberculous guinea pigs, whereas, of the protein obtained from it and recrystallized ten times, as little as four one-hundredths of a milligram sufficed to give an equally strong reaction."—*Science Service*

A NEW METHOD FOR THE QUALITATIVE TESTING OF CALCIUM IN SOLUTIONS CONTAINING STRONTIUM AND BARIUM

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The methods described in the various qualitative manuals for the separation and testing of calcium are unsatisfactory whenever the solutions contain strontium. Barium causes no difficulties. Perhaps the most used method is based upon the precipitation of the strontium as the sulfate with subsequent testing of the filtrate for calcium with ammonium oxalate. This method is satisfactory if the strontium sulfate is allowed to stand twelve hours before filtration. Strontium sulfate is not completely precipitated and, therefore, gives a test for calcium if the filtration of the strontium sulfate is made immediately after precipitation. Other qualitative methods for this separation of calcium from strontium have serious disadvantages, not the least of which is the alcohol required in the well-known chromate method. The aim of this research was to find a rapid and accurate method.

Principle of the New Method

The solution of the problem requires complete and instant precipitation of the strontium sulfate in a physical condition that permits immediate and perfect filtration. There are a few cases in the literature of the formation of compounds by special methods whereby complete precipitation is accomplished and the precipitate is in such a condition that it can be easily and immediately filtered. Thorium hydroxide in a granular, easily filtered condition is produced commercially in the manufacture of thorium salts by adding ammonium hydroxide to the solid crystals of soluble thorium salts.[1] A granular, easily filtered calcium fluoride was prepared by adding solid calcium carbonate to hydrofluoric acid.[2] "Compact, granular particles of aluminum hydroxide which are easily filterable and washable may be made by treating ammonium alum with dry ammonia gas at 75°."[3] The same principle was applied to this problem by treating the previously precipitated and washed carbonates of calcium, strontium, and barium with sulfuric acid.

Procedure Recommended for the Separation and Testing of Mixtures of Calcium, Strontium, and Barium

The solution of the nitrates or chlorides of the alkaline earth or ammonium carbonate group is treated with ammonium chloride and am-

[1] Lecture by guide during visit to Welsbach factory at Philadelphia.

[2] Berzelius, *Pogg. Ann.*, **1**, 20 (1824).

[3] Yamazaki, *J. Soc. Chem. Ind.* (Japan), **29**, 154 (1926). Through *C. A.*, **20**, 3335 (1926).

monium carbonate in the usual way. The precipitate of the mixed carbonates is filtered and washed in the usual way. Two-thirds of this precipitate is removed with a spatula and tested for strontium and barium by the well-known methods. A slight excess of $N/1$ sulfuric acid is added to the carbonates remaining upon the filter paper. The barium and strontium sulfates thus formed remain completely insoluble upon the paper. Calcium sulfate, in sufficient quantity for the test, goes into the filtrate. Whether or not any calcium remains upon the filter paper depends upon the quantity present. If much calcium is present the filtrate soon becomes turbid and a precipitate of calcium sulfate forms. This final test is entirely satisfactory if more than a very small quantity of calcium is present. Greater sensitiveness is attained by treating the filtrate containing the calcium sulfate with an equal volume of alcohol, whereby the calcium sulfate is more nearly completely precipitated. If only a very small quantity of calcium is present the filtrate containing the calcium sulfate must be made basic with ammonium hydroxide and then precipitated with ammonium oxalate. In the analysis of a mixture of groups, traces of iron and aluminum may be present. If so, the ammoniacal solution should be filtered before the ammonium oxalate is added.

Another way of conducting the analysis is to add the sulfuric acid to the dry residue from the evaporation of the unknown solution of calcium, strontium, and barium as chlorides or nitrates. Experiments showed that this variation was satisfactory but that it required a longer time than the method already described.

Sensitiveness of the Test

Molar solutions of the various reagents and test solutions were used except in the case of ammonium oxalate which was $N/4$. The carbonate precipitates of the calcium, strontium, and barium were obtained in the usual way. The rest of the procedure was as described above except that the entire residue of carbonates was used for the calcium test in each case. Ammonium oxalate was used as the final test for the calcium unless otherwise noted.

TABLE I

Grams of the elements present in each test			Result of the test for calcium with ammonium oxalate
Calcium	Strontium	Barium	
0.0	0.51	0.822	No ppt.
0.002	0.085	0.137	No ppt.
0.003	0.085	0.137	Light ppt.
0.004	0.085	0.137	Good ppt.
0.002	0.0425	0.0685	Good ppt.
0.003	0.17	0.274	Light ppt.
0.003	0.425	0.685	No ppt.

In all the above tests the carbonate precipitates were treated with only 10 cc. of $N/1$ sulfuric acid in order that the final volume of the filtrate after being made basic with ammonium hydroxide would not be much over 10 cc. However, in those experiments where the larger quantities of strontium and barium were present sufficient sulfuric acid was used to be in excess. The less the final volume the greater the sensitiveness of the test for the calcium. There was a little greater sensitiveness if the solution being tested for the calcium stood over night after addition of the ammonium oxalate. This modification was not quantitatively tested because a rapid method only was the aim of this work. Each of the above tests was completed in a total of 15 to 20 minutes.

It was found that greater sensitiveness was obtained by increasing the length of time of the standing of the sulfates in the sulfuric acid. For example, 0.002 g. of calcium in the presence of 0.822 g. of barium and 0.51 g. of strontium gave a very light precipitate if the sulfuric acid stood on the sulfates one hour before filtration. A duplicate of this experiment, except that no calcium was present, showed no precipitate when the test with the ammonium oxalate was made. This proves that the barium and strontium do not interfere by giving a test for the calcium. This increased sensitiveness obtained by the sacrifice of speed is not needed for ordinary work.

If the final test for the calcium is to be the immediate formation of a precipitate in the acid filtrate without the use of ammonium oxalate, 0.032 g. of calcium is needed in the presence of 0.137 g. of barium and 0.085 g. of strontium. However, 0.008 g. of calcium with 0.137 g. of barium and 0.085 g. of strontium gives a precipitate if the filtrate is allowed to stand an hour. If an equal volume of alcohol is added to the filtrate containing the calcium sulfate, 0.004 g. of calcium with 0.137 g. of barium and 0.085 g. of strontium gives a precipitate immediately and 0.001 g. of calcium gives a slight precipitate in 2.5 hours. Blanks containing no calcium do not precipitate even after twelve hours thus again showing that the strontium and barium do not interfere by giving the appearance of calcium.

Only a few of the many experiments that were made are given in this paper. It is hoped that the sensitiveness and the rapidity of the method are fully proved.

Summary

1. A new procedure is described for the qualitative separation and detection of calcium in the presence of the other alkaline earths.

2. A good precipitate for calcium can be obtained from a mixed solution containing 0.003 g. of calcium, 0.137 g. of barium, and 0.085 g. of strontium.

3. The total time required for an analysis is from 15 to 20 minutes.

4. Barium and strontium never give a precipitate at the place for the calcium.

5. Students in three different qualitative laboratories have used this method with accurate results whereas the same class of students made many errors with the calcium tests generally used.

6. The method requires only ordinary reagents and only the regular methods of qualitative manipulation.

Synthetic Butter Full of Vitamins Declared Possible. A butter substitute that will contain as many calories and more vitamins than the old-fashioned product of the cow can be made available at a low price, London scientists declare.

In view of the general shortage of dairy products, chief source of the vitamins necessary for health and growth, Drs. O. Rosenheim and T. A. Webster of the National Institute for Medical Research, have suggested to the scientific journal, *Nature*, a cheap and effective butter substitute. Fats from the livers of such readily available animals as sheep, calves, and oxen, they report, contain ten times the proportion of vitamin A that exists in cod-liver oil.

"The well-known skill of the margarine manufacturer," Dr. Rosenheim explains, "should enable him so to incorporate the liver fats with his product so as to convert a dietary article, already identical with butter in calorific value, into a cheap and palatable product of equal biological efficiency, so far as vitamin A is concerned."

The no less important rickets-preventing vitamin D, another variable constituent of butter, can be supplied by mixing in small quantities of irradiated ergosterol. This is a recently discovered product of great potency believed to be the parent substance of the anti-rachitic vitamin. After exposure for regulated periods of time to ultra-violet light, it is capable of curing human rickets in as small doses as from two to four milligrams daily.

"The margarine manufacturers," continues Dr. Rosenheim, "have therefore at their disposal, if they care to make use of them, means which should make a perfect biological substitute for butter accessible, without unduly raising the price of margarine. Moreover, by carefully controlled methods of manufacture, it should be possible to supply a product of constant vitamin content, superior in this respect to natural butter, the vitamin content of which depends on too many uncontrollable factors in the food supply of the cow."—*Science Service*

Cane Cream, New, Sweet Product of Southland. Cane cream, a new sugar by-product developed by the Bureau of Chemistry, has proved to be such a popular delicacy in the South that the government is now introducing it to northern cookery experts.

A deep brown in color, the new offering is more or less of a medium in flavor between the Canadian maple cream, a thick spread made from maple sugar, and the molasses sirup popular for use on pancakes. Experts claim the flavor retains to an unusual degree the taste of the original sugar juice. Whereas molasses is the juice remaining after the making of sugar by crystallization of the cane sap, cane cream is the whole juice—thick, creamy, and sirupy.—*Science Service*

THE TEST FOR CALCIUM WITH AMMONIUM OXALATE

ROBERT B. COREY AND H. W. ROGERS, CORNELL UNIVERSITY, ITHACA, NEW YORK

Introduction

Several methods are employed in elementary qualitative analysis for the separation of strontium from calcium and the subsequent detection of the latter. The one which appears to be in most general use is that involving the precipitation of strontium as sulfate and its removal by filtration, followed by the detection of calcium as calcium oxalate by adding ammonium oxalate to the filtrate. While using this method in elementary classes the attention of the writers was called to the fact that if strontium is present considerable uncertainty is introduced into the calcium test, in as much as an appreciable precipitate of strontium oxalate is almost always obtained. Calcium is, therefore, often reported when absent since the white strontium oxalate is indistinguishable in appearance from the corresponding calcium salt. Such confusion may be obviated to some extent through confirmation by means of a flame test. Nevertheless, it would appear to be much more satisfactory, especially from a pedagogic standpoint, if conditions could be so adjusted that the strontium oxalate precipitate would not form at all, and at the same time the sensitivity of the calcium test be not appreciably affected. The great difference in the solubilities of the oxalates of the two metals suggests that such an adjustment might not be impossible.

As early as 1886 Bloxam[1] pointed out that after strontium has supposedly been removed with sulfuric acid, the solution will still give a precipitate on the addition of an oxalate. Arzruni[2] remarked that the filtrate from the precipitation of strontium by a soluble sulfate will yield a precipitate of strontium oxalate. Ebler[3] noticed that in the separation of the alkaline earth metals strontium oxalate may come down with calcium oxalate when the filtrate from the sulfate precipitate is tested for calcium. He recommended diluting the filtrate with an equal volume of water before adding ammonium oxalate.

Experimental Part

To prevent the precipitation of strontium oxalate after the removal of strontium as strontium sulfate, the strontium-ion concentration in the filtrate must be reduced. This diminution might be effected (1) by allowing ample time for the complete precipitation of the sulfate and (2) by dilution. The effects of these two factors were studied qualitatively in the following experiments.

[1] Bloxam, *Chem. News*, **54**, 16 (1886).

[2] Arzruni, *Ber.*, **5**, 1044 (1872).

[3] Ebler, *Zeit. anal. Chem.*, **48**, 175 (1909).

To a 0.05 normal solution of $SrCl_2$ an equal volume of 0.5 normal solution of K_2SO_4 was added. The mixture was heated to boiling and the precipitate of $SrSO_4$ allowed to settle. Five minutes after precipitation a portion of the supernatant liquid was filtered off and tested as follows.

To 3 cc. of this filtrate 2 cc. of 0.5 normal $(NH_4)_2C_2O_4$ were added. The solutions were mixed and allowed to stand. In 10 minutes a precipitate appeared, and at the end of 20 minutes a fairly heavy precipitate (about 5 mg.) was present. Spectroscopic examination showed it to consist of strontium oxalate containing only a trace of calcium.

A second portion of the filtrate was diluted with an equal volume of water. To 3 cc. of the diluted solution 2 cc. of $(NH_4)_2C_2O_4$ were added. An appreciable precipitate appeared on standing for 20 minutes.

A portion diluted to three times its original volume gave a slight precipitate with ammonium oxalate after standing for 40 minutes.

Samples diluted further gave no visible precipitates whatever.

At the end of 10 minutes a second sample of the supernatant liquid was filtered off from the $SrSO_4$ precipitate and subjected to similar tests. In the case of the undiluted sample, the precipitate was not quite as heavy as before. That diluted to twice its volume gave a faint precipitate, but one which would hardly be considered a conclusive test for calcium. The sample diluted to three times its volume gave no visible precipitate at all.

Several additional samples of the supernatant liquid above the $SrSO_4$ precipitate were removed at 10-minute intervals and tested as outlined above. Standing for a time longer than 10–15 minutes made no appreciable difference in the results.

From these experiments it appears that the interference of strontium in testing for calcium with ammonium oxalate can be entirely avoided if the solution is allowed to stand for 15–20 minutes after the precipitation of $SrSO_4$ and if the filtrate from this precipitate is diluted to three times its volume before making the calcium test.

Although dilution effectively prevents the precipitation of SrC_2O_4 in the test for calcium, it has little effect on the sensitivity of the latter because of the exceedingly small solubility of CaC_2O_4. Experimental analyses showed that calcium is readily detected in a solution containing 1 mg. of the metal in the presence of 100 mg. of strontium. A parallel analysis made on a solution containing 100 mg. of strontium but no calcium gave no precipitate whatever in the calcium test.

Theoretical confirmation for the method suggested may be obtained from calculations based on the solubility products of strontium and calcium oxalates using the values published by Kohlrausch.[4]

This modification has been used by the writers in their classes for some time with very gratifying results.

[4] Kohlrausch, *Zeit. phys. Chem.*, **50**, 356 (1905); **64**, 129 (1908).

Summary

In the analysis of the alkaline earth group the removal of strontium as sulfate is incomplete to the extent that the filtrate from the sulfate precipitate will still yield a precipitate of strontium oxalate upon the addition of ammonium oxalate. In the customary procedure this precipitate may readily be confused with the test for calcium.

Strontium oxalate is not precipitated if 15–20 minutes are allowed for the removal of strontium sulfate and if the resulting filtrate is diluted to three times its volume before adding ammonium oxalate. Such dilution does not appreciably affect the sensitivity of the calcium test.

Test Garage Air for Deadly Monoxide Gas. How great is the danger of carbon monoxide poisoning to which garage employees are exposed? We read frequent accounts in the daily news about automobile owners who have committed involuntary suicide in their small private garages by running the engines when the doors are shut. Yet mechanicians work all day behind closed doors in large garages. How much of an industrial hazard are they exposed to?

Dr. S. H. Katz, of the U. S. Bureau of Mines, and Dr. H. W. Frevert, of the U. S. Department of Agriculture, have been endeavoring to find an answer to these questions, and they reported on their work before the recent meeting of the American Chemical Society.

The two investigators collected samples of the air from a large government garage in Washington and from a large commercial garage in Pittsburgh, and subjected them to chemical analysis. They found that the working conditions in the government garage, so far as the poisonous gas was concerned, were better than those in the commercial establishment. During the regular working day the concentration in the government garage never exceeded one part of carbon monoxide in ten thousand parts of air, while in the Pittsburgh shop the maximum was two-thirds again as much, or 1.64 parts in 10,000.

In neither establishment did the concentration reach the danger point, though during one hour the carbon monoxide in the Pittsburgh garage attained a "bad eminence" of 4.33 parts per 10,000 of air. This, it was stated, is enough to cause headache in some men.

The report adds, however, that the investigations were conducted under only average working conditions. In very cold winter weather, when the garage doors are likely to be kept more tightly closed, conditions may become more serious.—*Science Service*

CIVIL-SERVICE EXAMINATIONS

The United States Civil-Service Commission announces unassembled examinations for Associate Chemist and Biochemist. Applications must be on file at Washington, D. C., not later than December 6th.

The entrance salaries are $3000 and $3600, respectively.

Full information may be obtained from the United States Civil-Service Commission, Washington, D. C., or the secretary of the United States Civil-Service Board of Examiners at the post-office or customhouse in any city.

A LECTURE DEMONSTRATION OF DYNAMIC EQUILIBRIUM

GEO. M. KARNS, UNIVERSITY OF ILLINOIS, URBANA, ILLINOIS

It has been the experience of teachers of elementary chemistry that the presentation of the idea of dynamic equilibrium is one of the most difficult problems to be faced in the first year's work. In spite of the attention that is paid to this presentation it is not uncommon to find second-year students who have a very hazy idea of this fundamental concept. Many word illustrations may be presented which serve to guide the student in a correct line of thought but, as a rule, the illustrations which appeal to the visual sense, whether they are of the graphic sort or of mechanical contrivance, tend to firmly imbed the static idea in the student's mind. Demonstrations such as a poised system in balance, while showing how we may have an equilibrium with a large amount of one product and a small amount of the other, fail to show the student two active reactions, one forming the products used by the other, the amount of product existing at a given instant depending on the relative speeds of the reactions themselves. The apparatus illustrated here was designed for the purpose of presenting the idea of dynamic equilibrium to lecture groups. The results obtained in the class-room seem to indicate that it is a valuable aid to instruction.

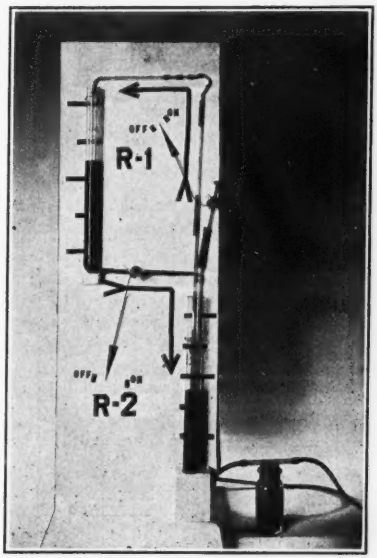


FIG. 1.—APPARATUS FOR DEMONSTRATING DYNAMIC EQUILIBRIUM

The apparatus (Fig. 1) consists of two vertical tubular vessels mounted on a board. The upper left-hand vessel is so arranged that its liquid contents may be allowed to drip into the lower vessel at a rate which may be governed by a stopcock. This passage of liquid from the upper vessel to the lower one has been called reaction number two and is so labeled on the apparatus. The designation, reaction number one, has been applied to the passage of liquid from the lower to the upper vessel. This is caused to take place by the operation of a simple air-lift pump (Fig. 2)

whose speed of operation may be regulated by a stopcock through which it is connected to a constant pressure device and the compressed air line. For the convenience of the operator and to call to the student's attention the importance of the speed of the reactions, pointers, which indicate whether the reactions are being accelerated or retarded, are fastened to the stopcocks. The speed of the reactions may also be noted by the student from the rate of drip from the upper vessel or from the frequency of pulsation of the pump. The attainment of equilibrium is automatically regulated by a given setting of the apparatus, for reaction number one slows down as the level in the lower vessel falls and reaction number two speeds up as the level in the upper vessel rises.

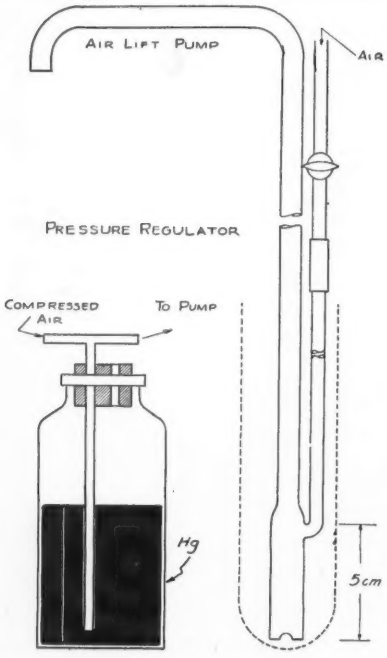


FIG. 2.—DETAIL OF LIFT PUMP AND PRESSURE REGULATOR

When the apparatus is in operation the stopcocks may be set for certain speeds for the two reactions and in a few minutes an equilibrium, the position of which will be shown by the relative amounts of liquid in the two vessels, will be reached. The equilibrium may now be shifted by altering the speed of either reaction and the shift is plainly indicated by the change in the liquid levels.

If it is so desired, both reactions may be made to proceed very slowly and in such case some time is required for the attainment of equilibrium. In contrast, if both reactions are speeded up as in the case of a *catalytic reaction*, the equilibrium point will be reached in a much shorter time.

The effect of removing one of the products of reaction, as would be the case when a volatile gas, a precipitate, or a slightly ionized substance is formed, may be illustrated by collecting the product of one of the reactions in a beaker and the reaction will proceed immediately to completion; that is, one of the vessels will be completely drained.

The dimensions of the apparatus may be varied to suit the conditions under which it is to be used. The apparatus illustrated here is about

eighty-five centimeters in height over all, with vessels about thirty-six centimeters in height. The vessels used should preferably be tall and narrow, as less change in volume is then required to give a marked change in liquid level. Prussian blue solution can be used very conveniently as the liquid.

UNITED STATES CIVIL-SERVICE EXAMINATIONS

The United States Civil-Service Commission states that the position of Professor of Chemistry at the Hygienic Laboratory, Public Health Service, Treasury Department, is vacant and that, in view of the importance of the position in the field of medical, chemical, and public health research, and to insure the appointment of a thoroughly qualified man for the work, an unusual method of competition will be followed to fill the vacancy. Instead of the usual form of civil-service examination, the qualifications of candidates will be passed upon by a special board of examiners composed of Dr. G W. McCoy, Director of Hygienic Laboratory; Dr. Charles L. Parsons, Chemical Engineer, Mills Building, Washington, D. C.; Dr. Julius Stieglitz, Head of Department of Chemistry, University of Chicago, Chicago, Illinois; Dr. Charles H. Herty, Chemical Foundation, New York City; Dr. Reid Hunt, Harvard Medical School, Boston, Massachusetts; and A. S. Ernest, Examiner of the United States Civil-Service Commission, who will act as chairman of the Committee. For the purposes of this examination all of these men will be examiners of the Civil-Service Commission.

The examination will consist solely of the consideration of qualifications by this special board. The minimum qualifications for consideration are a Ph.D. or an Sc.D. degree from a college or university of recognized standing and, in addition, at least five years of subsequent experience in scientific work, the major part of which must have been devoted to important chemical research. In addition, applicants must show that they have a reading knowledge of French and German. Each applicant must also submit with his application a complete list of publications of which he is the author, together with such reprints as may be available.

As the position is one of great responsibility, it is desired to secure the services of a person who has broad training and wide experience in various branches of chemistry as they relate to the public health and who is well qualified to handle work of a research, coöperative, and supervisory character. The applicant must possess some executive ability and be free from personal traits and interests that might interfere with the smooth operation of his division. In order to receive consideration, the candidate must demonstrate his capacity as a leader in chemical thought and research. With this end in view, in rating the applicant's papers, considerable weight will be given to his general reputation and to the opinion of qualified persons whose names he gives for reference.

The duties of this position will consist of planning, conducting, and supervising researches in the field of chemistry as it relates to the public health. The incumbent will have full charge, as chief, of the Division of Chemistry and as such will be responsible for the administration, personnel, and scientific work of that division.

The entrance salary of this position is $6000 a year. Promotion may be made without change in assignment up to $7000.

Qualified persons who wish to be considered for this vacancy should apply to the United States Civil-Service Commission, Washington, D. C., for Form 2600 which must be executed and returned, with a list of the applicant's technical publications and reprints of such of these publications as are available, to the office of the Civil-Service Commission at Washington not later than November 29, 1927.

AN INDIVIDUAL KIPP GENERATOR

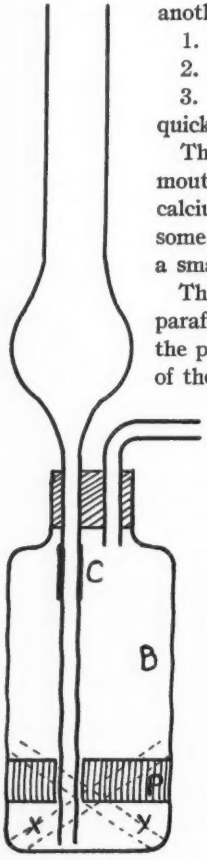
W. WESTWATER, UNIVERSITY OF NEBRASKA, LINCOLN, NEBRASKA

Practically every instructor of qualitative analysis has, at some time or other, designed a substitute for a Kipp gas generator for individual use. I am not an exception to the rule and hence I submit another which is practical for the following reasons.

1. It can be easily constructed by first-year students.
2. The cost of materials is low.
3. The reacting materials may be renewed easily and quickly.

The generator requires for its construction a small wide-mouthed bottle (we used a four-ounce bottle), a six-inch calcium chloride tube which held sixty milliliters of liquid, some glass and rubber tubing, one two-hole stopper, and a small amount of paraffin.

The bottle is divided into compartments by pouring hot paraffin on top of about a half inch of water. To keep the paraffin in place in case it does not adhere to the side of the bottle two small glass tubes (*X*, *Y*) are placed in the bottle so that the ends project above the paraffin. When the paraffin has cooled the water is shaken out and a hole is melted in the paraffin between the two small glass tubes by using a piece of hot glass tubing. The short lengths of glass tubing may be moved as soon as the paraffin is poured to allow proper spacing. The calcium chloride tube may be lengthened by fusing a piece of glass tubing to it but it is probably more practical for beginning students to use rubber tubing (*C*). The rest of the generator may be constructed by referring to the diagram. We use a bottle of the same size as a wash bottle for the gas and control the flow of the gas by using a screw clamp.



Individual Kipp Generator

To fill the generator with the solid, the stopper is removed and the generator turned on its side and the solid reagent placed on the portion marked *B*. The stopper is replaced and the liquid is poured into the calcium chloride tube.

Chemical Digest

ABSTRACTS

Revision of the Course of Study. WM. J. O'SHEA. *School*, **38**, 797 (1927).—The article represents Supt. O'Shea's interpretation of a new course of study for New York City schools.

The points to which he particularly directs attention are: "more emphasis" upon health education, the "recognized and enriched" social sciences, improved English through vigilant attention to it in all content subjects, an elementary science content brought up to date, and added emphasis upon nature study. He suggests further that the new course recognizes differing abilities of students by its content and so will help to make effective the plan of classifying students into bright, normal, and slow.

Two aims he considers of "paramount importance:" "the development of the emotional and esthetic aspects of the child's nature and the development of moral character." B. C. H.

A Liter and a Half of Brains. T. WINGATE TODD. *Science*, **66**, 123–5 (August 5, 1927).—Records kept by the Associated Charities of Cleveland since 1913 show an average brain capacity of 1480 cc. for the social ineffective up to 1917 when the level fell to 1410 cc. "During that year none but the veriest fool was left destitute; the others were all in the army or earning good wages in civilian life." In 1919 the average brain capacity of ineffectives rose to 1520 cc., fell in 1920 to prewar level, but in 1921 during a period of great industrial depression rose to 1550 cc. G. H. W.

Chemistry in the Progress of Medicine. F. H. CARR. *Chem. Age*, **17**, 27 (July 9, 1927).—Both pure and applied chemistry are necessary for the application of chemistry to medicine. The underlying principles of medical treatment are to aid the body to produce its own curative agents, remove causes, and secure rest. Some substances may have a direct curative effect, such as quinine and emetine.

The body hormones, insulin, adrenalin, thyroxin, the antitoxins, organic arsenic derivatives, Bayer 205 and Fourneau 309 are discussed briefly in regard to their discovery, uses, and constitution. Even though many of the medicinal products were discovered without the use of animal experiments requiring special technic, the day for discovering new drugs in this way is past. The relation between chemical constitution and therapeutic properties can be found only by the combined efforts of the chemist, physiologist, and physician. D. C. L.

Determination of Sulfur Dioxide in Foods. ANON. *Analyst* **52**, 415 (July, 1927).—A solution of 20 cc. concentrated HCl in 500-cc. water is boiled with a current of carbon dioxide to expel air and the sample is then introduced and distilled into hydrogen peroxide. The sulfuric acid produced can either be titrated or determined gravimetrically. D. C. L.

The Determination of Moisture by the Volatile Solvent Method. J. M. JONES AND T. MCLACHLAN. *Analyst* **52**, 383–7 (July, 1927). D. C. L.

The Great "Self-Expression" Delusion. A Passing Phase in Education. CHARLES K. TAYLOR. *Outlook*, **146**, 309 (July 6, 1927).—Opinion is swinging away from the idea that the child must not be compelled to do anything he does not want to do. G. H. W.

What Is Chemistry to Us? EDITORIAL. *Outlook*, **146**, 492 (Aug. 17, 1927).—Chemistry has more than an indirect connection with world affairs. The Institute of Chemistry held during July at Pennsylvania State College was intended to consider this connection. The meeting was a marked success. In the world of science chemists predominate in number over any other branch except medicine. G. H. W.

Report of the Fuel Research Board for 1926. ANON. *Chem. Age*, **17**, 78 (July 23, 1927).—The proper utilization of the coal resources requires a knowledge of the various types available, the purpose for which each is most suitable, and the method by which it can best be prepared for utilization. Distinct progress has been made on low-temperature carbonization but no practical application can be expected for several years. This is true because it must pass through four stages: (1) The method must be investigated under laboratory conditions. (2) The process is carried further by the erection of an intermediate-scale unit. (3) The erection of a full-scale unit ranging from 5 to 100

tons daily capacity. (4) A thorough investigation of the commercial possibilities by the erection of several units.

About 200 methods of low-temperature carbonization have been suggested, about 5 have arrived at the end of stage three and 2 are in stage four. The maximum yield of tar is produced at 550°C. The tar liquor is acid up to 500° and alkaline above 600°. An experimental plant using the Bergius hydrogenation process has been erected and is treating one ton of coal daily. An experimental process for the hydrolysis and fermentation of pentosan to produce alcohol has been evolved but the commercial development must occur at the source of the raw materials. D. C. L.

The Presence of Formaldehyde in Wood Smoke and in Smoked Foodstuffs. ERNEST HAROLD CALLOW. *Analyst*, **52**, 391 (July, 1927). D. C. L.

A Class-Room Experiment in Logical Learning. N. F. SHRIMP. *J. Appl. Psych.*, **11**, 117–26 (April, 1927).—A resumé of a study made to determine by experimentation the relationship between rate of learning and retention and also the value of the use of learning curves in increasing the rate of learning. The experiment was carried out in a Senior civics class of sixteen students. The instructor prepared a typewritten outline consisting of a series of problems with items for their solution. A series of questions without answers were prepared for the students' use. Thoroughness and logical learning were encouraged throughout the experiment while rote learning was discouraged. The results showed that the use of learning curves tended to motivate learning and that the more rapid the learning the more permanent the retention, the latter fact corroborating Norsworthy's results. S. R. P.

Predicting Abilities from Interests. DOUGLAS FRYER. *J. Appl. Psych.*, **11**, 212–25 (June, 1927).—To what extent are the interests of individuals suggestive of capabilities? The answer to this question has long been sought by those concerned with educational and industrial problems of personnel selection and guidance. In order to secure a measure of the relationship between the vocational interests or ambitions and abilities, Mr. Fryer made an investigation with a mixed group of sixty-five students in a western college; a group of sixty-seven women in an eastern college; three hundred and twenty young men already employed but applying at a bureau in New York City for vocational guidance; and a limited sample of seventeen women in an advanced vocational school to check upon differences in this field. "Interest expressions—vocational and educational ambitions—are of no significant value as criteria of abilities. This was found to be true both in the study of vocational and educational interests. In the guidance of a youth into a vocation or course of education his interest in the vocation or course of study is not at all indicative of ability in this vocation or course of study. It is only slightly suggestive of such an ability." S. R. P.

The Teaching of the Scientific Method. C. R. WARD. *Educ. Outlook*, **79**, 282 (August, 1927).—The author makes a brief analysis as to what is involved in the scientific method and then asks the question whether it can be taught directly in school. He says that the scientific method involves: (1) a difficulty which must be located; (2) previous experience which gives rise to suggestions to solve the difficulty; (3) an examination of the suggestions either by further reasoning or experiment and observation; (4) the consequent acceptance or rejection of such suggestions. The trained scientific thinker has the following attributes: (1) locates the difficulty exactly; (2) has a range and depth of suggestions to offer; (3) withholds his judgment until he has tested these suggestions; (4) makes his final decision in accordance with this. Mr. Ward comes to the conclusion that the scientific method can be taught directly and that schools should have this as a definite aim. He believes that the best method for doing this is by giving deliberate instruction in the methods of our great thinkers and so interesting the pupils in training their own minds. S. R. P.

The Cinema as a Civilizing Influence. JAMES GAULD. *Educ. Outlook*, **79**, 197–8 (July, 1927).—The author believes that the cinema is the one greatest civilizing influence today and that British educators have been too prone to under-estimate its influence. While conceding that many films are not what they should be, that the themes are occasionally low and degrading, that the film actors' lives may be questionable, he maintains that these constitute a minority. Many people are enabled to see places they can never visit; it has eliminated a problem involving use of leisure time; and many people who would otherwise spend time and money in drinking attend the cinema; and that people become acquainted with famous books who would never think of reading these same books. He concludes that the cinema, as a whole, inculcates a love of fair play and law and order, that it makes virtues of honesty and modesty, and that it is a civilizing influence affecting the lives of practically everyone. S. R. P.

The Definition of Teaching Problems on the College Level. DOUGLAS WAPLES.

Educ. Admin. and Superv., **13**, 391–8 (Sept., 1927).—The problems of instruction on the college level are practically unexplored. Comparatively little professional literature, either descriptive, analytical, or experimental, concerning college instruction is available. A tendency to investigate only those problems yielding objective data has caused many important problems to be ignored which are in need of investigation. The author, using the interview technic of Chapters, made an investigation in college instruction at the University of Pittsburgh two years ago. The 421 problems obtained from 95 instructors were classified into 54 types of which the following are typical: (1) How to obtain a fluent and accurate command of the subject taught; (2) how to supply deficiencies in the students' preparatory background without cheapening the course for the superior student; (3) how to present materials in sufficient detail with neither shortage nor excess; (4) how to make students discriminate between precise and hazy meanings; (5) how to teach students to study independently; (6) how to make individual contacts with members of large classes as a means of winning respect and directing individual work; (7) how to develop important traits such as respect for scholarship, open-mindness, accuracy, intellectual honesty, thoroughness; (8) how to administer examinations efficiently; and (9) how to obtain adequate facilities—library, laboratory, demonstration charts, mimeographing service, and the like.

S. R. P.

Rating Scales for Instructors. G. C. BRANDENBURG AND H. H. REMMERS. *Educ. Admin. and Superv.*, **13**, 399–406 (Sept., 1927).—What do your students really think of you as an instructor? Do you know or do you care to know? The authors of the above article asked these pertinent questions and attempted to make out a rating scale for instructors to be used by students. The ten following traits appear on the rating scale; (1) Interest in subject; (2) sympathetic attitude toward students; (3) fairness in grading; (4) liberal and progressive attitude; (5) presentation of subject-matter; (6) sense of proportion and humor; (7) self-reliance and confidence; (8) personal peculiarities; (9) personal appearance; (10) stimulating intellectual curiosity. Provision is made for rating each of these traits on a scale grading from very high to very low. The scale is of such a nature that ratings can be made quickly, impersonally, and more or less accurately.

S. R. P.

Change of Environment and the I. Q. FLORENCE M. TEAGARDEN. *J. Appl. Psych.*, **11**, 289–96 (Aug., 1927).—Can environment modify the I. Q.? Some data which partially answer this question have been gathered from a close study of two cases. The first measure of I. Q. was obtained six years prior to the last one. At that time conditions could have hardly been worse as regards social and moral features. Both cases were girls—one having an I. Q. of 73 on the first test and the other having an I. Q. of 77. After spending six years in an institution where moral, social, academic, and economic training are of the highest type, measurements of I. Q. show that it has remained remarkably stable in each case.

S. R. P.

The Thorndike Intelligence Tests and Academic Grades. DAVID GRAUER AND W. T. ROOT. *J. Appl. Psych.*, **11**, 297–318 (Aug., 1927).—This article is the resumé of a study involving 569 cases at the University of Pittsburgh. The purpose of the investigation was to determine the relation between the performance on the Thorndike intelligence examination and the academic grades over an entire college course of four years and also determine through case studies the conditions of correlation and non-correlation. Data from many individual case students are included. A moderate degree of correlation (0.39 ± 0.046) was found to exist between the Thorndike examination score and the average academic grade for the first two years with indications that this holds true for the entire four years of college. The authors concluded that the correlation between the Thorndike score and the average academic grade was too low to justify the exclusion of students from college on the basis of the Thorndike rating alone and that other intellectual elements, exclusive of those measured by the Thorndike test, are also determining academic success. The Thorndike tests were found to be very valuable in studying individual cases.

S. R. P.

The Scheduling of Teachers' Salaries. *Res. Bull. Natl. Educ. Assoc.*, **5**, 1–191 (May, 1927).—The bulletin discusses the factors involved in making out teachers' salaries schedules. Such factors as the nation's ability to lift teacher compensation to a professional level, the economic position of public school teachers, and guides to salary scheduling are discussed. Charts and tables are used freely. A selected, annotated bibliography on teachers' salaries is included. Teachers, administrators, and all those who are directly interested in this phase of education will find the bulletin invaluable.

S. R. P.

The Locarno Conference on Education. H. C. DENT. *Educ. Outlook*, **79**, 313–4

(Sept., 1927).—The Locarno conference on education was the fourth international conference of the Fellowship. Previous conferences have been held at Calais, Montreux, and Heidelberg. At the conference were gathered over twelve hundred people from every nationality and race of the earth. The general theme of the conference was to discover how best to set the child free from the restrictions, the conventions, the limitations of environment, and the inhibitions of personality. American thought was represented by Dr. Harold Rugg, Teachers College, whose subject was "Curriculum Making, Past and Present" and Dr. Carelton Washburne, Winnetka, Illinois, who spoke on "Freedom through Individual Mastery." The author summarized the chief outcomes of the conference as follows: first, the realization of the interdependence of the whole world; second, the realization that we must achieve for ourselves real, though relative, freedom before we are fit to hand the idea on to anyone else (teachers must be as free as possible intellectually, emotionally, and spiritually); and third, the realization that the search for the meaning of freedom and the means of attaining it must be scientifically conducted. Study the learning processes, study the child nature, study the laws of growth, drop the emphasis on how to teach, and place it more and more on how the child learns, insisted speaker after speaker. S. R. P.

Research. R. E. ROSE. *Science*, **66**, 117–22 (August 5, 1927).—The cost of academic research is high. A more critical view of its results should be taken. The institutions in which graduate work for a degree is allowed might well be limited in number as might the men allowed to take charge of such work. This type of research might be speeded up by impressing upon the students the desirability of less waste of time and also by providing more apparatus and manual help so that dish washing might not be a necessary part of the research workers' time consumption.

In industrial research the time factor may be over-emphasized but, on the whole, it comes nearer being satisfactory as to subject-matter than academic research.

The value of experience accumulated by the specialist is not adequately appreciated either in industrial or academic circles. G. H. W.

Chemistry and Precious Stones. G. EVERETT MARSH, JR. *Chem. Bull.*, **14**, 207 (Sept., 1927).—Chemists have for the last century and a half tried to produce stones similar to those found in nature. They have had remarkable success in the production of sapphires and rubies, many of which are more perfect than those found in nature. The gems have these same physical constants as the natural stones and the same chemical, crystallographic, and mineralogic properties.

During the last century a French school of chemists has been keenly active in the laboratory production of crystals of corundum. A brief history of the outstanding men, their work, and their methods is given in this article. Crystals as large as 100 carats (20 g.) are produced and their colors are many and varied. It is possible to duplicate perfectly the color of the topaz, aquamarine, kunzite, and alexandrite. All these corundums are superior to the natural product. The Burma, Ceylon, and Siam rubies are perfectly duplicated, some of which sell for $2000 per carat. E. L. M.

A Decade of Achievements by the National Education Association. A Report. *Sch. and Soc.*, **26**, 17–22 (July 2, 1927).—Since 1917, the N. E. A. has seen a 2000 per cent increase in its membership. The membership had been small since its organization in 1857, but had consisted of administrators in the field of education, and it was under the inspiration and leadership of this association that the public school idea made such great development. The coöperation and participation of teachers became an important and essential factor, and the moving of the headquarters to Washington enabled the association to take part in matters of far-reaching importance. In 1918, the possibility of the World War's disastrous effects on that which it had taken years to construct was realized, and so the officers of the association met many times, committees were appointed, and plans formulated.

The *Journal* and *Research Bulletin* of the association do much toward keeping teachers posted on recent investigations. The Research Division, organized in 1922, has become a sort of clearing house for all research agencies in schools and colleges in the U. S. Due to the extensive developments of 1917–27, even greater ones are to be sought during 1927–37. K. S. H.

The Broader Meaning of Intellectual Achievement. L. D. COFFMAN. *Sch. and Soc.*, **26**, 1–4 (July 2, 1927).—The responsibility for high intellectual achievement does not rest upon the teacher alone, but upon the student as well. The extent to which the student's point of view may have been enlarged, and his degree of interest and love for the things he has been studying, depends largely upon his own efforts. A teacher cannot create ability or attitudes in his students, but his own attitude, his remarks, and the philosophy he employs may be the making or unmaking of those who come under

his guidance. The joys and purposes of intellectual achievement have been missed if the products of higher education fail to possess feelings and attitudes that make for the bigger and better qualities of life. K. S. H.

Teacher Training in the Liberal Arts College. A. K. RISSLER. *Sch. and Soc.*, **26,** 46–7 (July 9, 1927).—A discussion as to the advisability of devoting the better part of a college career to the learning of the teaching profession. The author says, "so much of the prospective teacher's time is spent in learning how to teach, that by the time she has completed her college career, she hardly knows what to teach." The majority of the courses in any educational department overlap, thus necessitating much repetition. Because of this fact, many of the courses offered are considered a waste of time. The fault, however, lies not so much with the courses as with the state requirements. Outside of a course in methods or principles, and several weeks of supervised teaching and observation, little is necessary. True, a teacher needs some training, but let it be such that the question of what to teach will not be overshadowed by that of how to teach. K. S. H.

Segregation on the Basis of Ability. I. H. W. MILLER. *Sch. and Soc.*, **26,** 84–8 (July 16, 1927).—A special meeting of the Senate of the University of Michigan was called in an effort to determine what could be done to further benefit superior students. A report based on experiments was presented and, while the conclusions were neither complete nor final, the advantages which a superior student may derive because of segregation were set forth. Details of the two tests of segregation are given. It seems generally advisable to segregate high, average, and low students into classes by themselves, regardless of individual aims.

In the organization and administration of segregated groups, sections of both high and low students were given to each of five of the most experienced instructors. Thus, it was possible to compare the results obtained from these selected groups with those obtained from mixed sections. The instructors were interviewed daily by the secretary for the reactions of the day, and on these reactions curves were plotted each week and records kept. A committee gathered data concerning the previous history of the students, the more significant facts of which are mentioned. This article is concluded in the next issue. K. S. H.

Segregation on the Basis of Ability. II. H. W. MILLER. *Sch. and Soc.*, **26,** 114–20 (July 23, 1927).—Figures are given to illustrate the distribution of letter grades of the high and low sections on all the work of one semester. The characteristics of the high and low men are discussed, along with possible reasons for the existence of poor students. The writer cites his experience with freshmen, discounting an impression which at one time existed that an instructor of juniors and seniors uses greater skill and more energy in teaching his students than does an instructor of freshmen and sophomores.

The benefits derived from segregating students are given and, in concluding, the writer states that the method employed is, on the whole, satisfactory. K. S. H.

Character Education. M. BENNION. *Sch. and Soc.*, **26,** 157–60 (Aug. 6, 1927).—A discussion of the education for and the development of character. This requires developing, to the highest degree, all the powers an individual possesses as assets of character. Good health and good environment, particularly social environment, are as important as good heredity. Equally as responsible as the school for the development of character are the social agencies, and here the parent-teacher organizations should play a vital part. A teacher should not only have a clear understanding and appreciation of the moral issues of life, but should be capable of stimulating this same understanding and appreciation in the pupils. The school should be a place where the pupils may learn to live together and work for the ultimate good of society, for the sharing of responsibility does much in developing judgment and moral courage. A thorough knowledge of the society in which the child lives and is to live, if the child is to be educated to do his part in bringing about social progress, is essential. K. S. H.

The Lecture-Conference Method vs. Individualized Instruction. H. B. ENGLISH. *Sch. and Soc.*, **26,** 172–4 (Aug. 6, 1927).—A comparison is made of two methods of college instruction, based on an experiment recently reported from the State University of Iowa. The author disagrees with the statement that both methods are equally effective, on the grounds that the students were not selected and the teaching effectiveness of the teachers was not considered. K. S. H.

Local Activities and Opportunities

State University of Montana. Five members of the 1927 class will take up graduate work this fall: George Floyd at Cornell, H. E. Robinson at Pittsburgh, D. E. Kvalnes at Minnesota, A. E. Christensen and R. D. Stanley at Montana.

Wallace Windus, '25, who has been chemistry instructor at the Miles City, Montana, High School for two years, will take up graduate work at Illinois.

Dr. J. W. Howard has been promoted to a full professorship beginning Sept. 1, 1927.

The University of Nebraska. Dr. Samuel Avery on September 1st retired from the Chancellorship of the University of Nebraska after nearly twenty years' service. He will have a laboratory in the department of chemistry where he will devote himself to research, continuing on some problems which he put aside on becoming Chancellor.

Dr. William H. Adolph, formerly of Chee-Loo University, China, and located last year at Yale University, has been appointed to an associate professorship of chemistry in the University of Nebraska.

Dr. H. M. Harshaw of the University of Missouri and Dr. H. A. Pagel of the University of Minnesota have been appointed to instructorships in the department of chemistry of the University of Nebraska.

Arizona. Miss Louise Otis, M.S., Northwestern, and instructor in chemistry at Northwestern University, is spending the 1927–28 session at the University of Arizona. During this time she will be working on her Doctor's Dissertation dealing with the composition of certain plant gums, under the direction of Professor Ernest Anderson.

Dr. Homer LeRoy Shantz, professor of biology and head of the department of biology at the University of Illinois, has notified the Board of Regents of the University of Arizona of his acceptance of the Presidency of the institution, to become effective July 1, 1928.

Mr. O. E. Schupp, Jr., M.S., University of Arizona, and for the past two years instructor in chemistry here, has left for Yale University where he will hold a University Fellowship while he pursues work leading to the Ph.D. degree.

Dr. O. C. Magistad (Ph.D., Wisconsin), last spring accepted an associate-professorship in agricultural chemistry in the Agricultural Experiment Station and is conducting researches on the behavior of zeolites in alkali soils.

Dr. T. F. Buehrer, associate professor of chemistry, spent the second term of the summer session at the University of Texas, giving a course in quantitative analysis.

Miss Hilda Kroeger (B.S., Arizona, 1925), now a candidate for the Ph.D. degree in physiological chemistry at the University of Illinois, addressed the Arizona Section of the American Chemical Society, Sept. 28th, speaking on the subject, "Urinary Proteins."

Miss Rosalind Klaas (M.S., University of Arizona, 1927) has been appointed instructor in chemistry for the session 1927–28. For her Master's Thesis, Miss Klaas presented the results of her researches on the Composition of Cholla Gum, carried on under direction of Dr. Lila Sands and soon to be published.

Lexington Section, A. C. S. The 121st regular meeting of the Lexington Section of the American Chemical Society was held October 11th in Kastle Hall at the University of Kentucky. Dr. R. N. Maxson spoke on "The Dispersion of Soaps in Mixed Solvents." Dr. Maxson has been working with soap dispersions for about two years.

University of Pittsburgh. The chemistry department of the University of Pittsburgh has adopted a novel plan for this year's programs. Weekly meetings will be devoted to a discussion of "American Universities and Their Work in the Field of Chemistry." The following universities will be discussed: Illinois, Cornell, Columbia, Ohio State, Pennsylvania, Johns Hopkins, California Institute of Technology, and Toronto. A similar program on "European Universities and Their Work in Chemistry" is planned for 1928–29.

Cincinnati Section, A. C. S. The 292nd regular meeting of the Cincinnati Section of the American Chemical Society was held in the Chemical Auditorium of the University of Cincinnati, October 12, 1927, at 8 o'clock.

The speakers of the evening were Professor R. F. Reed, Director of Lithographic Research in the University of Cincinnati, and A. W. Broomell of the Cincinnati Chemical Co.

Professor Reed discussed the work he and his assistants are doing in Lithographic Research. Mr. Broomell attended the American Chemical Society Institute of Chemistry at Pennsylvania State College during the summer and gave a review of the work covered by that important conference.

Princeton. Last spring it was announced that the Public Service Corporation of New Jersey had placed at the disposal of Princeton University a fund for carrying on research in pure science and, particularly, in chemistry. The fund amounts to $10,000 each year for 5 years. For the present year the money is to be used in supporting the work of three men who have been called to Princeton. The men are: Mr. H. L. J. Backstrom as research associate with the rank of assistant professor, Dr. Waldo Westwater and Dr. R. T. Major as research assistants with the rank of instructor. Mr. Backstrom comes from the Nobel Institute in Stockholm where he has been working for the doctorate and assisting Professor Svante Arrhenius. His research interests are in the field of negative catalysis. Dr. Westwater did his graduate work at the University of California and taught last year at the University of Nebraska. His work at Princeton will probably have to do with the determination of dielectric constants of chemical compounds. Dr. Major received the doctorate from Princeton last spring. He spent last year abroad working in the laboratory of Professor Ernest Fourneau, the famous pharmaceutical chemist, in Paris and at the University of Berlin. His researches have dealt with the synthesis of organic compounds of possible therapeutic value. This year he will be associated with Professor L. W. Jones and will carry on some investigations on complex amine oxides.

Professor William Foster's book, "The Romance of Chemistry," has been greeted with universal interest and approval. The Century Company has recently ordered an additional printing. Also the Allen and Unwin Company of London have acquired the English rights to the book and are about to bring out an edition in that country.

The College Entrance Examination Board has appointed Professor Foster chief examiner in chemistry for the present academic year.

Professor H. S. Taylor spent part of the summer in Europe. He attended the annual meeting of the British Association for the Advancement of Science and visited the laboratories of some of the important German chemical industries.

The Howe prize in analytical chemistry was awarded last June to J. H. Wallace of the class of 1928. G. E. Kimball, also of 1928, received honorable mention.

It was interesting to note, in connection with the enrolment in freshman chemistry, that 187 men elected the course which includes laboratory work, while 66 elected the course consisting of lectures or recitations only and which was designed particularly for those who are interested in the science as a cultural study. The implication is that the great majority

begin the study of chemistry with some plan in mind involving a knowledge of both the theoretical and practical aspects of the subject.

At the commencement exercises in June, fellowships in chemistry were awarded to be held during the present academic year. H. N. Alyea, B.S., Princeton '25, was awarded a Charlotte Elizabeth Procter Fellowship. Mr. Alyea has been engaged in research work in the field of catalysis since graduation in 1925. During 1925–26 he was the Sayre Fellow in Applied Chemistry, and during 1926–27 he held an American Scandinavian Fellowship at the Nobel Institute in Stockholm. V. C. Rogers, B.S., University of Utah '24, M.S., Utah '25, A.M., Princeton '26, was awarded the Harvard Fellowship. This year Mr. Rogers will continue his work on the addition products of triphenylmethyl with various organic compounds. W. S. Niederhauser, A.B. , Oberlin College '24; A.M., Oberlin '26, was given the new Albert Plaut Fellowship. He will assist Professor Hulett in his work on standard cells. J. C. Elgin, Ch.E., University of Virginia 24', was appointed DuPont Fellow; H. A. Beatty, B.S., Princeton '26, Fellow in Chemistry; W. L. Ruigh, B.S., Princeton '27, Sayre Fellow in Applied Chemistry.

While in Europe this summer Professor A. W. C. Menzies attended meetings of the British Association for the Advancement of Science, and the Society of Chemical Industry. At the latter he served as representative of the American Section, and in that capacity extended an invitation to the Society to hold the next annual meeting in New York. The invitation was formally accepted by the Chairman.

Professor N. H. Furman, B.S., Princeton '13, Ph.D., Princeton '18, who is on leave of absence during the present term, writes from Utrecht, Holland, that he has been traveling about Europe for the past four weeks visiting various industrial chemical works. Later he intends to go to Zurich where he will carry on some research work. Professor Furman was much impressed with the great strides which the French are making in the manufacture of organic synthetics. At the Etablissements Kuhlman at Villers-St. Paul, France, 1200 different compounds are produced. Particularly impressive was a plant capable of turning out 20 tons of acetic acid a day from crude acetaldehyde made from calcium carbide.

Dr. G. St. J. Perrott, M.A. Princeton '15, was recently appointed Superintendent of the Bureau of Mines Experiment Station at Pittsburgh.

New York University. The Department of Chemistry has opened the fall session with a large increase in the Staff and added facilities for instruction and research. Last year's staff of forty members has been increased to sixty. The following new members of the staff are teaching fellows who are also working in the department for higher degrees: George Frederick Auwater, B.S., 1927, Cooper Union; Sylvester James Broderick, M.S., 1927, Grove City College; Claiborne E. Brogden, A.B., 1927, Duke University, N. C.; Mortimer Danzer, B.S., 1926, Columbia University; (Miss) Ray Dee Fine, B.S., 1923, Carnegie Institute of Technology; (Mrs.) Wendela Liander Friend, M.A., 1922, Columbia University; Philip A. Hrobak, B.A., 1926, St. Procopius College; Arthur E. Kimberly, B.S., 1926, George Washington University; De Witt Clinton Knowles, B.S., 1927, Brooklyn Polytechnic Institute; Aron N. Leibovici, C.E., 1924, Polytechnic Institut of Bucharest; Anna Ruth Milligan, B.S., 1927, Carnegie Institute of Technology; Oscar O. Miller, B.S., 1927, Grove City College; Edward John Powers, B.S., 1926, Columbia University; Samuel Prigal, B.S., 1927, Washington Square College, New York University; Morris Schachnowitz, B.S., 1926, Washington Square College, New York Univ.; Gunther H. Schmitz, B.S., 1926, New York University; Rose Shulman, M.A., 1927, University of Southern California; Edith P. Silbert, B.S., 1927,

University of Graz, Austria; Florence S. Tabor, B.S., 1923, Skidmore College; Isaac Worth Wade, B.S., 1924, Southern Methodist University; Henry Madison Walter, M.S., 1926, University of Maryland; George M. Wiedeman, B.S., 1927, Kansas State Agricultural College; Arthur S. Williams, A.M., 1916, University of S. C.

A number of teaching fellowships for the February-September division are still available. The duties approximate ten hours per week as laboratory assistant in undergraduate courses in inorganic, analytical, and organic chemistry, and in the conduction of small quiz sections. Holders of these positions will be expected to take up advanced courses in the department of chemistry at Washington Square College toward the degree of Ph.D. Free tuition is allowed for three full courses ($162.00) per year. Salary $600.

Application blanks and any further particulars desired may be obtained from Professor Kendall, Administrative Chairman of the department.

Graduate courses covering the fields of organic, inorganic, analytical, and physical chemistry have been supplemented by several additional courses, including microanalysis and photochemistry.

Additional laboratory facilities to accommodate three hundred more students have been provided and six new research laboratories are now fully equipped for work in X-rays, metallography, organic chemistry and micro-analysis, and photochemistry.

During the summer the members of the staff were variously occupied at home and abroad. James Kendall, F.R.S., Dean of the Graduate School, and Chairman of the department of chemistry, attended the Institute of Chemistry at Pennsylvania State College, heading the discussion on inorganic chemistry there. Dr. A. Marie Farnsworth also attended, giving a graduate course in the theory of quantitative analysis. Professor John A. Mandel spent the summer in Berlin with some of his former colleagues. Dr. J. B. Niederl renewed his stock of micro-analytical technic in the laboratory of Professor Emich in Austria. Dr. Ralph H. Muller, on leave of absence since April, was engaged in radiation studies in the laboratory of Professor Franck in Göttingen. Dr. Wm. West renewed scientific acquaintances in Great Britain and Germany.

On July 21st, Professor Kendall addressed the Institute of Chemistry on "The Abuse of Water." He addressed the Philadelphia Section of the American Chemical Society on the same subject on October 20th. The Rochester Section invited him to speak before that section on October 3rd. "Some Separations, Old and New, by the Ionic Migration Method" was presented by Professor Kendall, and was repeated before the Syracuse Section the following day.

University of Arkansas. The department of chemistry has expanded this fall into larger quarters. Organic chemistry has been moved into another laboratory, alongside of agricultural chemistry which has been there in the past. This has left in the Chemistry Building space for the expansion of the laboratory classes in the inorganic, analytical, and physical chemistry classes.

Mr. O. L. Osburn from Iowa State University begins his duties as instructor in chemistry here.

Jacob R. Meadow, who received his master's degree here last June, is now instructor in science at Arkansas College.

Maryland Section, A. C. S. The Maryland Section of the A. C. S. will act as host to the Washington, Philadelphia, Virginia, Delaware, and South Jersey Sections at an intersectional meeting to be held at the University of Maryland, College Park, Md., on November 26th. At that time the University's newly erected Chemistry Building will be dedicated.

The new laboratory is a four-story structure, erected at a cost of $210,000. Additional funds for the purchase of furniture and equipment have been do-

nated by friends of the institution as follows: *Organic*, Dr. H. A. B. Dunning of Hynson, Westcott and Dunning; *Analytical*, Dr. Samuel W. Wiley of Wiley and Co., Inc.; *General Chemistry*, Dr. and Mrs. M. L. Turner; *Physical*, Dr. Alfred R. L. Dohme of Sharpe and Dohme; *Colloid*, Mr. C. G. Campbell of the Kewaunee Mfg. Co.; *Industrial*, The Chemical Alumni of the University of Maryland.

The dedicatory exercises to which the public is invited will be held at 10:00 A.M. Dr. Edgar F. Smith of the University of Pennsylvania will be the principal speaker. A special luncheon has been arranged.

The afternoon session will be devoted to the intersectional program. The preliminary program is as follows:

2:00 P.M. Sectional Meetings.

Physical and Inorganic Section:

1. The Work of the Geophysical Laboratory—Dr. A. L. Day.
2. The Permeability of Narrow-Pored Sieve Membranes—Dr. Leonor Michaelis.
3. Some Factors Influencing Gelation of Pectin Solutions—Dr. P. B. Myers.
4. A New Method of Measuring Osmotic Pressure—Dr. J. C. W. Frazer.

Organic and Biological Section:

1. Oxidation-Reduction Potentials and Their Significance—Dr. W. M. Clark.
2. Chemotherapy—Dr. Carl Voegtlin.
3. Title to Be Announced—Dr. Treat B. Johnson.

There will be one other paper by a nationally known speaker.

Industrial Section:

1. Theoretical Considerations of the Constitution of Aromatic Azo Compounds—Dr. L. A. Pinck.
2. The Behavior of Ammonium Sulfate at Temperatures between 100° and 200° When Heated in Platinum, Silver, and Pyrex Glass—Dr. R. F. MacCrackan.
3. Synthesis of Different Acridine Derivatives—Dr. F. Jensen.
4. Methods and Applications of Chromium Plating—Dr. Wm. Blum.
5. Influence of Sulfur on Azo Dyes—Dr. E. Emmet Reid.
6. Alcohol as a Constituent of Motor Fuels—Dr. W. C. Moore.

Agricultural and Fertilizer Section:

1. The Relation of Agricultural Chemistry to Industry—Dr. C. A. Browne.
2. The Proper Use of Fertilizers—Dr. H. J. Patterson.
3. The Mechanical Condition of Fertilizers—Dr. W. H. Ross.

Section of Chemical Education—Symposium on Teaching Elementary Chemistry:

1. Laboratory Work in High-School Chemistry—Dr. L. W. Mattern.
2. Sectioning on the Basis of Ability—Dr. R. A. Baker.
3. Sectioning on the Basis of Previous Training—Dr. C. C. Carpenter.
4. The Use of the Electron Theory in Teaching Chemistry—Dr. R. E. Rose.

Other papers have been promised but titles have not yet been received.

6 P.M. Informal dinner (price $1.50 per person), after which Dr. C. H. Herty will deliver an address.

A ladies' program is also in preparation.

To reach College Park by rail come either to Washington, D. C., or to Baltimore, Md.; thence by Baltimore and Ohio R. R. to College Park Station. Trains leave Washington 8:15 A.M., arrive College Park 8:31 A.M.; leave Baltimore 8:20 A.M., arrive College Park 9:25 A.M.

College Park can also be conveniently reached by auto over good roads from all important cities of the East, since it is on the Washington-Baltimore Boulevard, 31 miles from Baltimore and 7 miles from Washington.

It is essential that the Committee knows not later than November 18th, how many plan to be present. Please notify Dr. N. E. Gordon, University of Maryland, College Park, Md.

Recent Books

An Introduction to Organic Chemistry. ROGER J. WILLIAMS, Ph.D., Associate Professor of Chemistry, University of Oregon. D. Van Nostrand Co., Inc., 8 Warren Street, New York, 1927. ix + 565 pp. 14 × 21.5 cm. $3.50.

A new attempt to rationalize our modern science of organic chemistry and thereby lay before the beginner in our colleges more clearly the more important phenomena which we consider as essential for a fundamental course in organic chemistry. The important relationships of organic reactions are discussed in the accepted order and the various theories which are considered acceptable today are touched upon briefly. When one considers the rapid and rigid expansion that organic chemistry is undergoing today, the reviewer believes that the present treatise has been presented with good judgment and the text should be welcomed by institutions desirous of having the subject presented in a lucid manner.

The writer of the book has a real appreciation of the scientific method, but appreciates the limitations of the average student and does not, therefore, weave into his text discussions which should never be considered until the student has acquired a good fundamental knowledge of the basic principles of organic chemistry. The writer lays great emphasis on the chemical behavior of organic compounds. This is an excellent feature and much better than the introduction of complicated reactions and preparations involving rare organic combinations whose real significance the average student will fail to grasp.

Following each chapter are introduced problems designed to test the student's knowledge of his subject. The solution of these problems calls for a real knowledge of the ground work covered by the student and serves as a means of evaluating his scientific intelligence and resourcefulness.

There are many important features which add to the general interest in a text of this character, namely, suggestions offered about books to read, references to important journal literature, and advice as to how to use standard works and chemical journals. In other words, we find introduced throughout the book a progressive method of teaching which immediately interests us. The reviewer believes the book will meet with success.

TREAT B. JOHNSON

First Principles of Chemistry. F. W. DOOTSON, M.A., Sc.D., F.I.C., University Lecturer and Demonstrator in Chemistry, Cambridge, and A. J. BERRY, M.A., Fellow of Downing College, University Demonstrator in Chemistry, Cambridge. Cambridge University Press, London, 1927. vi + 339 pp. 43 figures. 13 × 19 cm. $2.00.

According to the preface this book is designed to accompany lectures in the universities of England, with the thought that it would minimize time for the students otherwise taken up by writing notes in class.

According to the preface, "General principles and general methods have been emphasized throughout, and details have only been stressed where they have a special significance." This does not appear to be carried out consistently.

Much attention is given to such topics as "Hydrogen Ion Concentration" and the "Chemistry of Colloids." Discussion of the Periodic Law is very brief, while discussions of the Laws of Multiple and Reciprocal Proportions are omitted.

A study of the book discloses the fact that it may very well serve the purpose stated by the authors. In the opinion of

the reviewer, however, it would not serve the purpose for which textbooks of elementary chemistry are used in this country.

The text is unattractive and uninspiring in appearance. It contains a negligible number of illustrations. There is no variety in type.

The various chapters contain practically no modern teaching devices such as thought questions, problems, review questions, summaries, etc.

The content of the text does not conform to what may be considered a standard elementary course in chemistry as represented by the course developed by the Division of Chemical Education. The text contains a considerable amount of physical chemistry. In general, it appears too difficult for a beginning text, unless used as suggested by the authors.

The book would not be suitable for use in high schools in this country nor is it especially well adapted to the use of freshmen in college who have not already had a year of high-school chemistry.

The criticisms as suggested with respect to the use of the book in this country have no particular relation to the use as designed by its authors and suggested above.

H. A. CARPENTER

Four Thousand Years of Pharmacy, An Outline of the History of Pharmacy and the Allied Sciences. CHARLES H. LAWALL. J. B. Lippincott Company, Philadelphia, 1927. xv + 665 pp. 64 illustrations. 13.5 × 20 cm. $5.00.

This volume, as the subtitle indicates, is not, strictly speaking, a history of pharmacy, since much of the material contained therein deals with the history of other sciences as shown by the following subtitles to some of the eleven chapters into which the whole is divided: "Science in Embryo," "The Kindergarten of Science," "The Origin of Universities," "A Century of Alchemistic Frenzy," "Beginning of the Renaissance," "The Century of Paracelsus," "The Birth of Chemistry," and "Beginnings of Modern Science." The foregoing extraneous material has, however, been so well interwoven with that portion dealing with the history of pharmacy that it enhances rather than detracts from the value of the book to the pharmacist.

English-speaking pharmacists, in general, and teachers of pharmacy, in particular, have long felt the need of a book of this character written in English. Heretofore, the English-speaking pharmacist has only had available "Chronicles of Pharmacy" by A. C. Wootton and "Pictorial History of Ancient Pharmacy and Medicine" by Herman Peters, translated from the German by William Netter, both of which are excellent books in the fields which they are intended to cover, but neither of which tell the complete story.

Professor LaWall's book is well written, the illustrations are good and to the point, and in addition to filling a want on the part of the pharmacist, it will be found to be interesting and profitable reading for the chemist.

A. G. DUMEZ

Laboratory Exercises for a Brief Course in Chemistry. LYMAN C. NEWELL, Boston University. D. C. Heath and Co., New York, 1927. x + 152 pp. 13.5 × 20.5 cm. $1.00.

This is a looseleaf manual with blank sheets inserted for laboratory notes. The exercises are divided into two groups: minimum and supplementary. The minimum group "consists mainly of exercises suggested by a Committee of the American Chemical Society (see JOURNAL OF CHEMICAL EDUCATION, May, 1927) as a minimum laboratory requirement for a year of chemistry." This group contains sixty-two exercises of which thirty-eight are starred as essential and of these five are teachers' exercises. There are also sixty-two supplementary exercises which offer material for (1) substitute experiments, (2) a longer

course, (3) extra laboratory work, and (4) teacher demonstration.

Questions are omitted from the laboratory exercises but precise directions are given for observing results. "Specific instructions are given at the close of each exercise for writing notes." The instructions are sometimes rather general as in Exercise 9, Hydrogen, page 23, and at times consist of very specific questions as for Exercise 10, page 25. We doubt whether omitting questions from laboratory exercises, even at the end, will result in more satisfactory laboratory work or more accurate records as claimed by the author. Our experience with high-school pupils is rather the other way. Much written work is required today in all studies in a modern high school and if the chemistry teacher expects high-grade written work, it must be reduced to a minimum and answers to specific questions appear to be the most satisfactory for average pupils.

We note as excellent features of this manual: many supplementary exercises for pupils and teachers, very clear directions, clear-cut diagrams. It will repay high-school teachers and others to examine this attractive new manual.

A. P. MINSART

Guide to Chemistry. SAMUEL WINSTON, M.A., Boys' High School, Brooklyn, N. Y. Globe Book Co., New York, 1923. v + 96 pp. 12.5 × 18.5 cm, Paper cover. Listed at 34 cents; postpaid 44 cents.

"This book is intended to guide teachers and students in a systematic and complete review of elementary chemistry as taught in our best secondary schools."

The author rightly states that a course in chemistry should consist of numerous laboratory experiments performed individually; this supplemented by lecture-table demonstrations and a study of at least one standard textbook. His syllabus of topics conforms sufficiently to those most prevalent in modern high schools. The same may be said for his sequence of topics. With each of his twenty-eight topics a summary is made, which is followed by an average of ten questions. The questions cover the subject-matter quite thoroughly, are good, but are such as the average thoroughly trained teacher of chemistry will ask his classes spontaneously during recitation or at examination. By this it is intended to imply that this Guide to Chemistry is applicable more to the use of pupils and insufficiently trained teachers of chemistry than to experienced ones. This is not intended to detract from the usefulness of the book.

There are twenty pages of laboratory exercises, fifty-three of the latter, which could serve as an outline of a laboratory course in chemistry in many high schools, and also be useful to a teacher in formulating good experiments.

There are twenty-one pages of examination questions covering eleven examinations, each of these being divided into five groups from each group of which the pupil is supposed to select one or more questions. The relative values of parts of the questions are given on the basis of ten for the whole question. These questions can be of considerable value to all teachers, from the one carrying a teaching load of many subjects in the small high school to the experienced teacher of chemistry in the large high school. All teachers are prone to use stereotyped forms of questions and this "Guide" will help them to vary both the subject-matter and the language of the question.

The "Guide to Chemistry" concludes with seven pages of model answers.

There is a great deal of material similar to that found in the "Guide to Chemistry," to be found in the summaries, questions, and problems at the close of the chapters of modern high-school texts on chemistry. The reviewer and his colleagues use these when occasion arises and time permits. Perhaps the greatest value of this pamphlet lies in the fact that the guiding material of the chemistry textbooks is brought into a single booklet which will fit into teacher's and pupil's side-pocket. Undeni-

ably great usefulness can be attached to "Guide to Chemistry" by many teachers, and by all pupils if they could be induced to follow it.

J. HOWARD GRAHAM

A Laboratory Book of Elementary Organic Chemistry. ALEXANDER LOWY, Ph.D., Professor of Organic Chemistry, University of Pittsburgh, and WILMER E. BALDWIN, M.S., Instructor in Organic Chemistry, University of Pittsburgh. John Wiley and Sons, New York, 1926. x + 182 pp., with 77 figures. 21 × 28 cm. Cloth, net, $3.00.

This book is arranged to accompany "The Introduction to Organic Chemistry" by Lowy and Harrow and is intended for use in courses in organic chemistry taken by premedical, predental, engineering, and mining students, as well as by chemistry students. The purpose of the book, according to the authors, is "to acquaint the student with the important types of reactions, properties, and relationships of the various classes of compounds." The directions for the various experiments are clear and well written and the drawings of apparatus to be used are unusually attractive. The general make-up of the book is excellent and few errors were noted. The list of experiments is essentially that found in the current laboratory manuals of elementary organic chemistry. The reviewer noted nothing especially new in the types of experiments chosen or the methods described. On the whole the purpose as stated in the preface is well fulfilled.

A number of special features of the book may be noted. The pages are unusually large. Following each experiment is a page of questions so spaced that the answers may be written in. This leaf is perforated and is to be separated from the book and handed to the instructor for correction. At the same time space is left in the body of the directions of the different experiments for recording the student's experimental results. This leaf is not perforated. It would seem that this arrangement of two systems of keeping the notes is a clumsy one.

Another feature of the book is the large number of illustrations of apparatus which are included. These are taken from dealers' catalogs of chemical glassware and apparatus. Thus on page 21 are pictured the various types of distilling flasks and fractionating columns and on page 22 we find thirteen condensers of both the laboratory and the industrial types. There is, however, no discussion accompanying them, although some attempt is made to cover this point by means of questions. It seems to the reviewer that these illustrations can be of little value to the student without some discussion of the various types of apparatus and their uses. In many cases the laboratory apparatus pictured is now considered obsolete in most laboratories and one wonders if this is not true also of some of the industrial types illustrated. Several schematic diagrams of industrial processes are shown as, for example, the refining of petroleum, p. 15, and the manufacture of ethylene, p. 34. The reviewer confesses that he finds difficulty in visualizing industrial processes from diagrams such as these and wonders if they will have any meaning for the student.

The large number of illustrations included and the unusual size of the pages are responsible for the relatively high cost of the book, $3.00. The reviewer does not feel that these special features are of sufficient value to justify the cost.

FRED W. UPSON

Chemistry. W. H. BARRETT, M.A. Oxford University Press, American Branch, New York, 1927. viii + 148 pp. 21 figures. 12 × 18 cm. $1.75.

"The main ideas behind the 'General Science' movement in schools are the broadening of the basis of school science and the bringing of it into a closer relation with the facts of everyday life." With this in mind the author has presented some of the more important facts of chemistry in a manner that should be readily

understood by the general reader. It is in no sense a technical book, though it describes a number of chemical processes and discusses some of the more important theories and laws.

Beginning with a brief account of the scope of chemistry and its historical development, including the phlogiston theory and Lavoisier's experiments on combustion, the author continues through a total of thirteen chapters in which are discussed such subjects as oxygen, water, acids, bases and salts, lime, carbon, fuels, nitrogen, nitric acid, sulfur, and salt. Among the principles and laws are included the laws of constant composition and multiple proportions, the atomic and ionic theories, the Brownian movement, the existence of molecules, the Periodic Law and atomic structure.

The book is well and entertainingly written. The discussions of the existence of molecules, the calculation of atomic weights, and the structure of the atom are especially clear and easy to follow. Taken as a whole the book shows the importance of chemistry to everyday life in the contacts that it makes and should be of especial value to general science teachers.

GEO. W. SEARS

Handbook of Scientific and Technical Societies and Institutions of the United States and Canada. *Bulletin of the National Research Council*, No. **58.** American section compiled by CLARENCE J. WEST AND CALLIE HULL. Canadian section compiled by National Research Council of Canada. First edition. National Research Council, Washington, D. C., 1927. 304 pp. 17 × 24.5 cm. Paper, $3.00; Cloth, $3.50.

"The purpose of this publication is to present a ready guide to those scientific and technical societies, associations, and institutions of the United States and Canada which contribute to knowledge or further research through their activities, publications or funds. The tendency has been towards a broad interpretation of these requirements, and the list, therefore, is not to be regarded as a selective one. Only those government institutions are included which administer private funds. Organizations directly controlled by universities or colleges have been omitted because it is expected that they will be covered by the forthcoming publication 'American Universities and Colleges,' to be issued by the American Council on Education."

Industrial Research Laboratories of the United States Including Consulting Research Laboratories. *Bulletin of the National Research Council*, No. **60.** Compiled by CLARENCE J. WEST AND ERVYE L. RISHER. Third edition, revised and enlarged. National Research Council, Washington, D. C., 1927. 153 pp. 17 × 24.5 cm. Paper, $1.00.

"The continued demand for information regarding industrial research laboratories has made it seem advisable to issue a second revision of the list originally published in Number 2 and revised in Number 16 of the *Bulletin of the National Research Council*. The original publication, compiled in 1920 by Mr. Alfred D. Flinn, Secretary of the Engineering Foundation, listed about 300 industrial laboratories. The first revision prepared in August, 1921, by Miss Ruth Cobb of the Research Information Service, listed 526 laboratories. The present revision contains data for 1000 laboratories.

As in the earlier lists, all information given in this publication has been obtained directly by correspondence and statements are based upon information supplied by the laboratories. An endeavor has been made to follow the phraseology of the laboratories wherever possible; the names are given in the style used by the company with regard for spelling and abbreviations. No investigation has been made to ascertain the character of any laboratory listed, nor the quality of the work done."

Laboratory Layouts for the High-School Sciences. *Bureau of Education Bulle-*

tin, No. **22.** A. C. MONAHAN. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 1927. v + 31 pp. 15 × 23 cm. 13 illustrations. Paper, $0.10.

Includes discussion of layouts, equipment and stock for chemistry, physics, biology, and general science laboratories.

Grain through the Ages. GRACE T. HALLOCK AND THOMAS D. WOOD, M.D. Illustrated by Jessie Gillespie. The Quaker Oats Company, Chicago, Illinois, 1927. 96 pp. 13.5 × 18.5 cm. 8 illustrations. Free.

A companion booklet to "Hob O' the Mill," published in 1926. Suitable for younger school children. Frankly intended to advertise Quaker Oats but educational in content and presentation.

List of References on Higher Education. *Bureau of Education Library Leaflet*, No. **35.** Prepared in the Library Division, JOHN D. WOLCOTT, Chief. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., Sept., 1927. 40 pp. 14.5 × 23 cm. Paper, free.

Trends in the Development of Secondary Education. *Bureau of Education Bulletin*, No. **26.** EUSTACE E. WINDES. Superintendent of Documents, U. S. Government Printing Office, 1927. 41 pp. 14.5 × 23 cm. Paper, $0.10.

The Industrial Medicine Chest. Abbott Laboratories, North Chicago, Illinois, 1927. 30 pp. 13.5 × 19.5 cm. Paper, free.

Filtration in Chemical Laboratories. Carl Schleicher & Schull, New York, 1927. 63 pp. 14.5 × 21.5 cm. Paper, free.

Transmutation of Elements May Supply Earth's Heat. The heat of the earth as used in mountain building, the melting of rocks into lava, and that which is radiated into space, may come from the evolution or transmutation of one element into another. This is the suggestion recently made to the National Academy of Sciences by Dr. W. V. Howard of the University of Illinois.

Dr. Howard's studies have been concerned with the odd-numbered elements, that is, the elements that have odd numbers when arranged in the orders of their weights, beginning with hydrogen, the lightest, as number one. This number of an element is called its atomic number. Many elements consist of mixtures of what the chemist calls isotopes. The isotopes of a given element are all the same element but their atoms have slightly different weights. Dr. Howard has worked out a series of rules by which the isotopes of elements that have not yet been successfully divided may be predicted.

These relationships together with his experimental results lead Dr. Howard to think that the odd-numbered elements may have actually been formed from the lightest isotopes of the even-numbered elements. According to modern ideas of the structures of the atoms of matter, this could be accomplished by the loss from the first element of a proton to form an atom of hydrogen, while the atom remaining would be that of an odd-numbered element.

As the process would be accompanied by the liberation of heat, Dr. Howard thinks that this is sufficient to account for much of the earth's heat.—*Science Service*

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